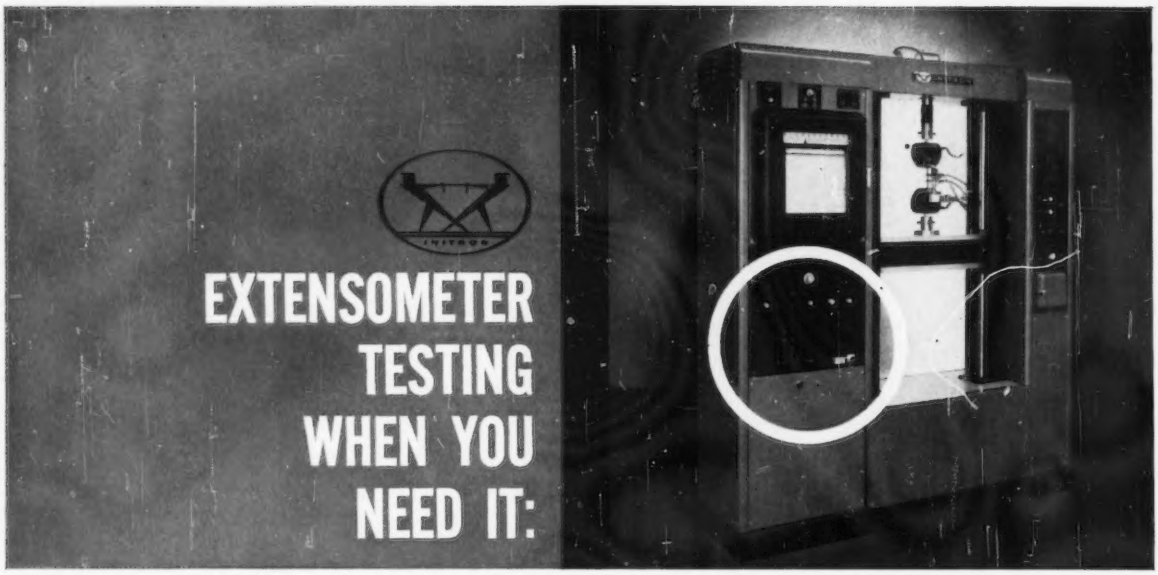
ASTM Bulletin

Third Pacific Area National Meeting . . . 5
Materials in the Aerospace Age 16
ASTM, Materials, and Progress 20

EDITORIAL DEPARTMENT FB
UNIVERSITY MICROFILMS D6
313 N FIRST ST
ANN ARBOR MICH



EXTENSOMETER TESTING WHEN YOU NEED IT:

the Instron XY recorder makes it as simple as flipping a switch!

When you want to use extensometers for certain testing applications . . .

. . . you don't have to buy a new tester (if you already have an Instron).

. . . you don't have to subject your Instron to costly modification.

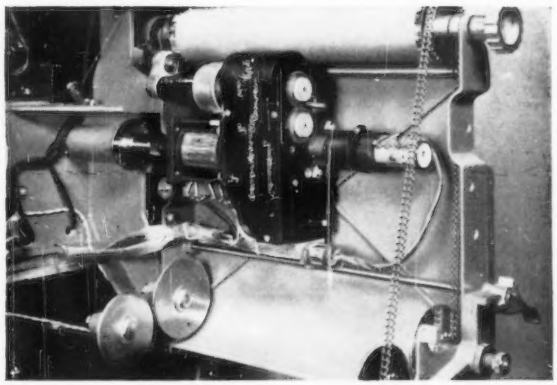
All you have to do is add this field-proven, high-precision accessory — the XY Chart Drive System — and you have a superbly efficient servo system which lets you change over, instantly, from sample elongation by grip separation — to extensometer measurement, at the flip of a switch!

Here's one more example of what we mean when we say you can do more with an Instron. And — you get this incomparable flexibility in testing only if and when you need it. This is an optional accessory — not a standard item built into the Instron to add to your expense whether you need it or not.

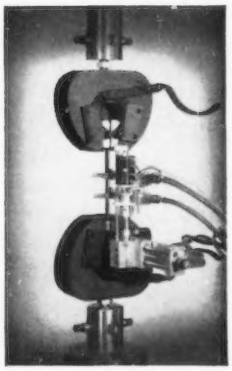
The XY Chart Drive Accessory — what it is:

a high performance servo system for driving the chart of the Instron recorder. Operable from most types of extensometers, including differential transformers, small synchros, resistance potentiometers and strain gauges.

Varying degrees of magnification, depending on extensometer type and gear ratio for everything from metals to miracle plastics.



Unlimited chart travel to enable switching from extensometer to time drive for relaxation measurement.



This accessory performs equally well with all Instrons, no matter what their vintage. Installation is no problem.

For complete information on high precision tensile testing (whether or not it involves extensometers) write us today.

INSTRON
ENGINEERING CORPORATION
2506 WASHINGTON STREET, CANTON, MASS.

YOU CAN DO MORE WITH AN INSTRON

The unusual versatility of this fine testing instrument is greatly extended by Instron's complete range of special accessories, which can be added as you need them. In addition to the XY chart drive system, they include: automatic digital readout • environmental cabinets • quick-change crosshead-speed selector • variable speed drive • high temperature equipment • load pacing • automatic cycling controls. Write for the complete Instron catalog.

FOR FURTHER INFORMATION CIRCLE 385 ON READER SERVICE CARD

ASTM BULLETIN

December 1959 **Number 242**

Telephone: LOcust 3-5315 **Cable Address: Testing, Philadelphia**

Reg. U. S. Pat. Off.

Raymond E. Hess
Editor
A. Q. Mowbray
Assistant Editor
Frank Y. Speight
Features Editor
George A. Wilson
Production Editor, ASTM Publications
Albert L. Batik
Advertising Manager

OFFICERS

———Board of Directors———
President
F. L. LaQue
Vice-Presidents
A. A. Bates M. N. Clair
Directors
Term ending 1960
C. L. Clark
A. E. Juve
J. H. Koenig
R. E. Peterson
R. W. Seniff
Term ending 1961
P. A. Archibald
W. L. Fink
H. M. Hancock
L. A. O'Leary
R. D. Thompson
A. C. Webber
Term ending 1962
A. B. Cornthwaite
C. L. Kent
H. C. Miller
C. F. Nixon
H. D. Wilde
I. V. Williams
Past-Presidents
R. A. Schatzel R. T. Kropf
K. B. Woods

———Executive Secretary———
R. J. Painter

COMMITTEE ON PAPERS AND PUBLICATIONS

This committee has authority in all matters affecting the acceptance, rejection, editing, and publication of papers, committee reports, and discussions. The committee also acts in an advisory capacity to the Board of Directors on publication matters in general.

R. E. Hess, *Chairman*

Robert Burns William Lerch
C. A. Carpenter E. C. Shuman
Thomas Hazen A. C. Smith, Jr.
F. M. Howell C. R. Sutton
W. T. Lankford R. J. Wiesching

Corresponding Members from Pacific Coast District

F. J. Converse R. E. Davis

TECHNICAL PAPERS

Segregation in Aluminum–13 Per Cent Uranium Castings—D. Peckner. *Castings were relatively homogeneous on a macroscopic scale* 51

Design Studies of Capsules for High-Temperature Irradiations—John H. Stang, William H. Goldthwaite, and Bruce W. Dunnington. *Large uncertainties are encountered in control and measurement of specimen temperature and heat generation* 54

The Use of Ultrasonics in Testing Irradiated Fuel Elements—John M. Fouts. *Unbonded areas between the uranium core and the aluminum can are located* 60

Improvements in ASTM Flammability Test Method—*Technical Note* by G. E. Eysenbach and J. J. Gouza 62

Control of Thermal History of Polyethylene Test Specimens—A. M. Birks and A. Rudin. *The control method described provides test specimens with uniform properties* 63

Extra Durability of Paint on Low-Alloy Steels—H. R. Copson and C. P. Larrabee. *Paint coatings are more durable on high-strength, low-alloy steels than on carbon steel or copper steel* 68

Demulsibility Test for High-Viscosity Oils—E. W. Brennan. *A report of Technical Committee C on Turbine Oils of Committee D-2 on Petroleum Products and Lubricants* 75

A Method for Determining the Demulsibility of Lubricating Oils—Paul D. Metzger. *New test is proposed for determining the ability of an oil to separate from a mixture of oil and water* 77

Torsion Pendulum Method for Determining Crystallinity and Void Content of Tetrafluoroethylene Resins—N. G. McCrum. *A torsion pendulum is used to determine torsion modulus and thus provide a basis for determining both crystallinity and void content* 80

ARTICLES

Third Pacific Area National Meeting 5
Materials in the Aerospace Age—Lieut. Gen. B. A. Schriever 16
ASTM, Materials, and Progress—F. L. LaQue 20
Management's Changing Responsibilities—Howard K. Nason 28
Standardization in India—William R. Pabst, Jr. 31
Committee Week 32
Measuring the Appearance of Aluminum Surfaces—R. V. Paulson 33
Does Management Get Full Value from Purchasing?—Mark W. Cresap, Jr. 35
Proposed Specification for Sealing Compounds for the Building Trade (Polysulfide Base or Equivalent) 46

DEPARTMENTS

ACR Notes 43
Actions on Standards 44
Bookshelf 84
Coming Technical Papers 30
Deaths 108
District Activities 40
Editorial 24
Government Standards Changes 115
Index to Advertisers 118
Index to ASTM Bulletin, 1959. 85
Laboratory Supplies & Equipment 111
Material Questions 24
New ASTM Publications 26
New Members 94
News of Members 102
Other Societies' Events 116
OTS Reports 100
Random Samples 83
Schedule of ASTM Meetings ... 25
Standards at Work 29
Technical Committee Notes 36
Your Committee Officers 34

ASTM Bulletin is indexed regularly by Engineering Index Inc.
ASTM Bulletin is available on microfilm from University Microfilms, Ann Arbor, Mich.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ASTM Bulletin, published eight times a year, January, February, April, May, July, September, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the Headquarters of the Society, 1916 Race St., Philadelphia 3, Pa. Subscriptions, United States and possessions, one year, $3.50, two years, $6.00, three years, $8.50; Canada, one year, $4.00, two years, $7.00, three years, $10.00. Other countries, one year, $4.50, two years, $8.00, three years $11.50. Single Copies—75 cents. Second-class mail privileges authorized at Easton, Pa.

This publication is authorized to be mailed at the special rates of postage prescribed by Section 132.123.

© Copyright 1959, by the American Society for Testing Materials.

MEASURE TENSION AND COMPRESSION LOADS

With Precision Force Gages By Hunter

Bond-Strength Test for Laminates in Test Lab.

Thousands of Hunter Mechanical Force Gages are now in use in laboratories, design departments, inspection departments, on production lines, and in the field. Accurate to within ±0.5 of full scale, these precision instruments can be hand-held or used in fixtures to measure tension and compression loads.

The indicator (no "follower" used) can be made to hold maximum reading until released by a "finger-touch" reset tab or the indicator can be made free moving—all by means of a control button. If a "hold-at-maximum" feature is not required, the instrument can be supplied without control button.

Gages are available in 13 models in Series L type for measuring load ranges from 0-500 grams to 0-30 pounds and in 6 models in Series D type for measuring load ranges from 0-50 pounds to 0-500 pounds. Six attachments and a compact wood case come with each gage. Prices are low enough to permit any company to purchase and evaluate. Many companies have purchased one, discovered myriad uses, and have reordered dozens.

For details, write for Bulletin 750c.

Testing Camera Springs In Production.

Testing Aircraft Pedal Controls in the Field.

Testing Sewing Machine Presser Feet in Production.

Testing Aircraft Manual Control in the Field

Testing Grip Strength of Crimped Terminals on Wire Connectors in Production.

Testing Carton Opening Load Requirements in the Inspection Lab.

These Force Gages are specified in many test standards

HUNTER

HUNTER SPRING COMPANY

A Division of American Machine and Metals, Inc.

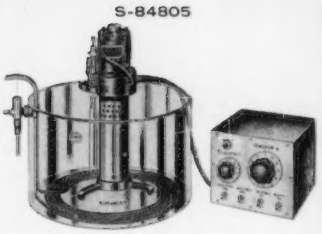
20 Spring Avenue, Lansdale, Pennsylvania

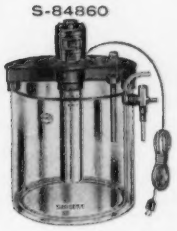
SPRINGS • STAMPINGS • QUALITY CONTROL EQUIPMENT

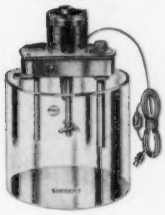
FOR FURTHER INFORMATION CIRCLE 386 ON READER SERVICE CARD

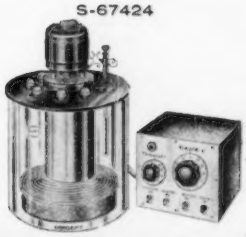
A complete line of Sargent LABORATORY BATHS DESIGNED for your specific needs

precise—economical—multi-purpose









FIVE WATER BATHS

S-84810 WATER BATH—Constant Temperature, Full Visibility, Thermonitor Controlled, 0.01°C, Sargent.

S-84805 WATER BATH—Constant Temperature, Full Visibility, 0.01°C, Sargent.

S-84860 WATER BATH—Constant Temperature, Full Visibility, 0.1°C, Sargent.

S-84870 WATER BATH—Constant Temperature, Full Visibility, Economy Model, 0.25°C, Sargent.

S-84880 LIQUID CIRCULATOR—Constant Temperature, 0.1°C, Sargent.

VISCOSIMETER BATHS for Kinematic Viscosity Measurements

S-67424 VISCOSIMETER BATH—Kinematic, Double Wall, High Precision, 0.02°F, Sargent.

S-67428 VISCOSIMETER BATH—Thermonitor Controlled, Kinematic, Double Wall, High Precision, 0.02°F, Sargent.

Write for Sargent Bulletin T on Temperature Controlling, Measuring and Recording Instruments

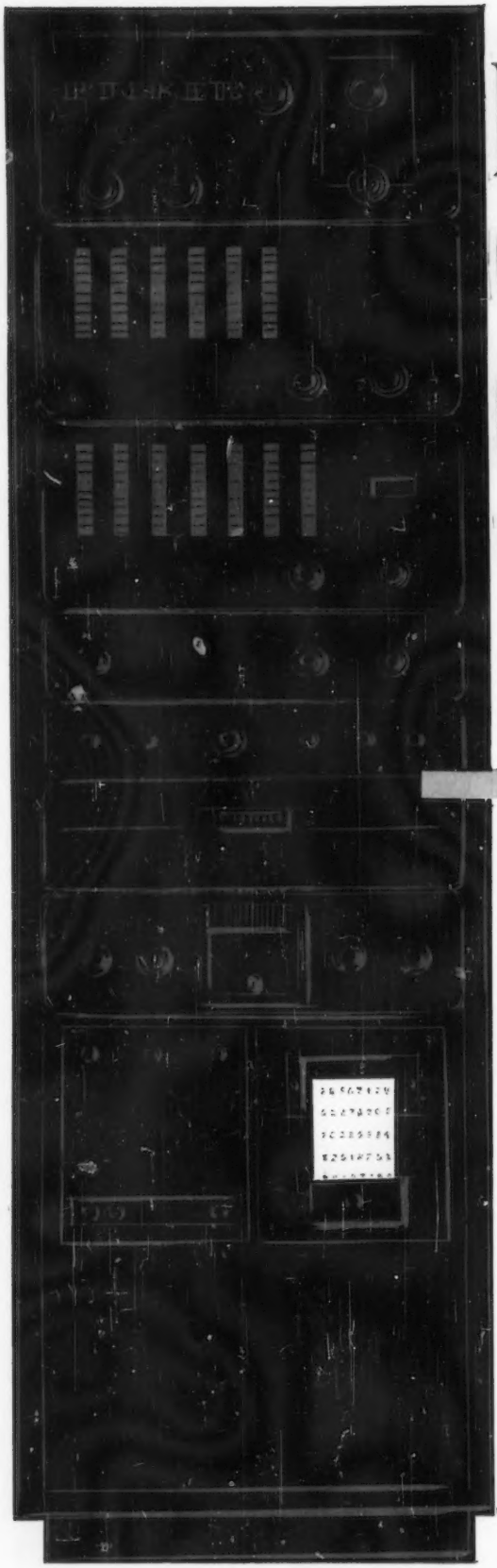
SARGENT

SCIENTIFIC LABORATORY INSTRUMENTS • APPARATUS • SUPPLIES • CHEMICALS

E. H. SARGENT & COMPANY, 4647 W. FOSTER, CHICAGO 30, ILLINOIS

DETROIT 4, MICH. • DALLAS 35, TEXAS • BIRMINGHAM 4, ALA. • SPRINGFIELD, N. J.

FOR FURTHER INFORMATION CIRCLE 387 ON READER SERVICE CARD



new PICKER electronics for diffraction with digital printout

into this fine equipment have gone all the design skills which distinguish Picker medical and industrial x-ray equipment.

behind it stands the Picker service organization—a nationwide network of local sales and service depots staffed with trained engineers—to assure dependable performance and uninterrupted functioning.

Get the story from your local Picker man. There's probably a District Office near you (see local phone book) or write Picker X-Ray Corporation, 25 South Broadway, White Plains, New York.

Picker nuclear

FOR FURTHER INFORMATION CIRCLE 388 ON READER SERVICE CARD

ASTM BULLETIN

Research and Standards for Materials

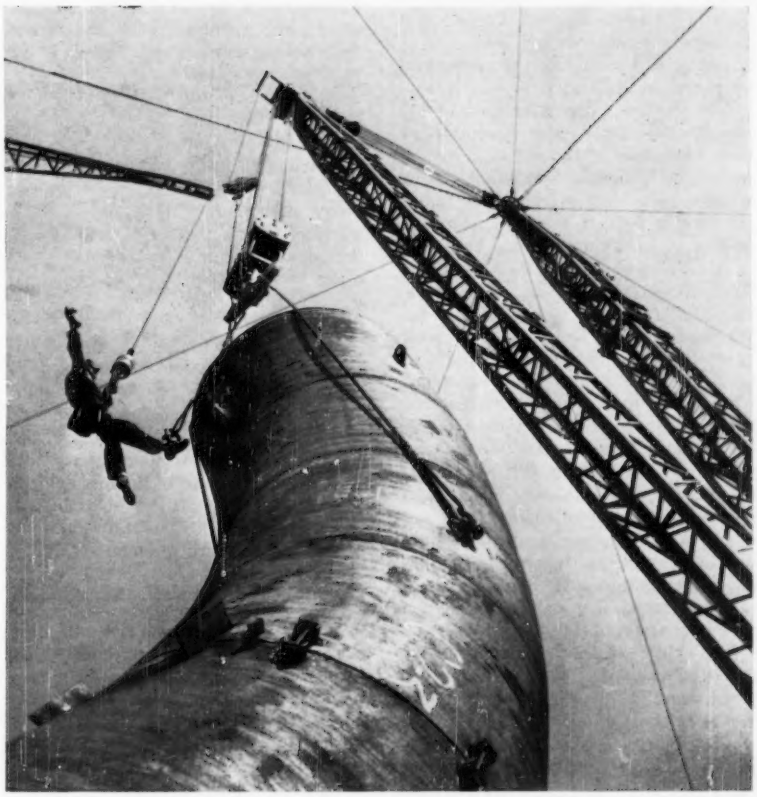
Number 242 December 1959

Third West Coast National Meeting Covers Broad Range of Materials

No meeting in the history of the Society illustrated so well its broad scope of activity as the Third Pacific Area National Meeting held in San Francisco, Oct. 12–16, 1959. While the emphasis in many sessions was on the extreme environments that materials are now asked to withstand in this age of rockets, jets, missiles, reentry nose cones, atomic power plants, and high-temperature industrial uses, other sessions were directing attention to perhaps less glamorous but certainly no less important problems of materials for our nation's airports, highways, dams, industrial plants, homes, and waterfront structures. Other groups concerned themselves with radiation, spectroscopy, use and disposal of industrial water, air pollution control, and other equally urgent problems. The Second Nuclear Problems Forum gave men from industry a chance to exchange views and be brought up to date on what the Society's committees are doing in this field.

High point of the week was the President's National Luncheon honoring Frank L. LaQue, at which Lieut. Gen. Bernard A. Schriever was the guest speaker. President LaQue's remarks, which he entitled "ASTM, Materials, and Progress," emphasized the theme that progress depends on advances in materials. "One can instantly bring to mind," said Mr. LaQue, "some scientific or engineering development that has been, or still is, dependent on improvements in materials." To illustrate, he observed that "Further advances in the economical generation of power from nuclear sources will depend more on improvements in materials and the way they are used than on solutions of problems in the realm of atomic physics.

"The extent to which man will be able to journey into outer space and to return safely," he continued, "... will be controlled principally by the solutions of materials problems."



Courtesy Standard Oil Co. (N. J.)

Rockets Are Not the Only Things Going up.

A tape-recorded message from the Society's Executive Secretary, Robert J. Painter, who was continuing his convalescence at Chestnut Hill Hospital, realistically welcomed the guests and visitors. Your reporter, who was behind a potted palm, had the feeling that Mr. Painter was at the rostrum.

General Schriever, Commander of the Air Research and Development Command, in an address entitled "Materials in the Aerospace Age" underscored the Air Force's heavy dependence on the perfection of new materials in everything from conventional aircraft to rocket motors and reentry nose cones. He stated that ASTM standards are an integral part of many military specifications, and many Air Force procurement contracts directly reference ASTM standards. He urged continued voluntary activity by ASTM in research and standardization for advanced materials. The addresses by General Schriever and Mr. LaQue appear elsewhere in this Bulletin.

West Coast Meeting

Five interesting addresses were presented at luncheons organized for different industrial groups: statistics, petroleum and chemical, electronics, industrial water, and cement and concrete. Further information about these will be found later in this article.

"What impresses me most is the intensity of interest in the technical committee work," remarked a senior Staff member at midweek. Fifteen technical committees and their subcommittees held a total of almost 200 meetings, getting their work under way for the coming year. The 52 technical sessions, with five or six running concurrently throughout the week, drew many visitors from the East as well as from the western states. Registration during the week was just over 1300—including 619 members, 187 committee members, and 495 visitors.

The Hostess Committee entertained almost 150 ladies who accompanied their husbands to the meeting with a week-long program. Beginning with a coffee hour each morning, the ladies attended a fashion show on Monday; took a 49-mile tour of San Francisco on Tuesday; and a "Tour of the Three Bridges"—Oakland Bay, Richmond-San Rafael, and Golden Gate—on Wednesday. On Thursday, they took a cable car to Fishermen's Wharf for lunch, and on Friday probably spent what money they or their husbands had left in the inviting San Francisco shops. On Tuesday evening, the Social Committee arranged for a Chinese dinner and tour of Chinatown which was enjoyed by a party of 132 men and women. A similar expedition on Thursday evening provided an opportunity to do some nightclubbing in San Francisco, and then to the Top of the Mark for a view of the city.

The exhibit of testing apparatus and laboratory supplies was an important educational adjunct of the meeting. About 35 booths were occupied by 28 exhibitors with a wide variety of apparatus. Visitors were particularly interested in the many new devices on display. More than 600 registered to visit the exhibit only.

Many took the opportunity to see plants and laboratories in the area, through visits organized by a special committee of San Francisco area members. A very popular trip was that to the General Electric Co. Vallecitos Atomic Laboratory for research and development on atomic products and the site of the General Electric–Pacific Gas and Electric Company's Atomic Power Plant, which holds AEC License No. 1. Twenty-four different trips were offered by the Plant Visits Committee.

Luncheons

Statistics

Who wants to be average? Cultural barriers must be overcome to establish quality control in a democracy such as ours, where the individual is king. In striving for the norm set by quality control procedures, we are forced to minimize individual differences. These points were made by Frank Squires, quality control consultant, in his address at the statistics luncheon. Mr. Squires illustrated some of the problems of selling quality control to the people who must carry it out. He pointed out that while quality control has been well proved as the best way to achieve maximum productivity with assurance of quality it is necessary to overcome the reluctance of the workers to aim for what some might consider a sameness approaching mediocrity. Where is the pride in accomplishment that formerly marked the true craftsman? Now the goal is to make every piece just like every other piece—no piece should be different from any other by more than the limits set by quality control.

Squires

Mr. Squires, with his delightful British accent, which he characterized as stemming from the Far West (west of Vine Street, Los Angeles—as contrasted with the Middle West, extending from the Delaware River to Vine Street), held his audience with his fervor and evident strong conviction that quality control can work wonders with the right kind of effort and regard for human factors.

Petroleum

World sources of petroleum were surveyed at the petroleum luncheon by T. L. Lenzen, director and vice-president, Standard Oil Co. of California. Mr. Lenzen stated that in 1959 world production is expected to be about 20 million barrels per day. About 8 million are produced in the United States, 3½ million in Latin America, and half a million in Canada, for a total of 12 million barrels per day in the Western Hemisphere. In the Eastern Hemisphere, the Middle East produces about 5 million barrels per day, the USSR and its satellites about 3 million, and the balance comes from Western Europe, Africa, and Indonesia.

Lenzen

He pointed out that oil is found most plentifully in areas where it is least needed and, conversely, is scarcest in areas where the demand is largest. Demand—or consumption—is most strongly influenced by population and level of industrial development, particularly the latter. Of the 20 million barrels per day expected to be produced this year, about half will be consumed in North America, and about 18 per cent in Western Europe. The USSR and its satellites, though not so highly industrialized but with substantially larger populations, will use nearly 3 million barrels per day. The Middle East, which accounts for more than half the world's reserves and about one-fourth of the world's production, will consume only about 3 per cent of the world total. The striking disparities beween consumption in the producing areas and production in the consuming areas make oil the most important single item in international trade. Mr. Lenzen stated that America's preeminent position in the world industry, advantageous as it is, makes for problems as well as benefits. He classified the problems as industrial, international, and intra-national. The most important of the industrial problems is the world-wide oversupply, although it is necessary to continue to look for sources, both in this country and abroad, and to continue to create new plant capacity. Internationally, relations between producer and consumer nations, old political quarrels, and the Cold War are but some of the things that affect the oil industry. Their effects range from petty annoyances to matters of life and death—economically for huge enterprises, politically for nations, and literally for human beings. Among the intra-national problems, Mr. Lenzen included the rising tide of nationalism, the drive for economic self-sufficiency in many parts of the world, and, indeed, the protectionist trend in our own country as evidenced by import controls.

Mr. Lenzen suggested the following three subjects for thoughtful consideration: *"First:* The fact that the U.S. with only about 12 per cent of the world's reserves, produces 39 per cent of the world's crude oil each day, and consumes very nearly as much oil as the rest of the world combined. Even as net importers of oil we are using our reserves at a far greater rate than the rest of the world. *Second:* Consumption in this country is growing more rapidly than our domestic reserves. If the relationship between our reserves and our production is not to deteriorate still further, we must import in ever-increasing quantities. *Third:* Many of the countries that supply us crude oil are almost wholly dependent upon petroleum revenue for political and economic stability. If we cannot help them

find markets for the one commodity they have to sell now, they may not be in our camp when our own supplies of oil run low and we need them."

Electronics

Reliability of complex, modern space vehicles with their myriad components can be achieved only by careful adherence to a quality control system. This was emphasized by J. A. Chartz, president of the Western Electronic Manufacturers Assn., speaking at the electronics industry luncheon. Mr. Chartz pointed out that technology had advanced exponentially ever since we broke the "oat" barrier with the development of the steam engine in the 19th century. The steam engine enabled man to travel at previously unheard-of speeds up to 100 mph, greatly exceeding the 25-mph top speed of horses, the fastest conveyance for all previous ages. Space vehicle speeds in the thousands of miles per hour illustrate the rapid pace of modern technology.

Chartz

Mr. Chartz emphasized the importance of the West Coast electronics industry, which already is producing one-quarter of the nation's electronics output. The industry needs the kind of help ASTM can give it in setting standards to reduce costs and achieve maximum reliability.

Water

Water has always been a material of primary concern to the navies of the world. The use of water for steam for propulsion, then the preparation of drinking water from the sea, and now the production of breathing oxygen for crews in long-submergence submarines by distillation and electrolysis of sea water have broadened and intensified the interest of navies in water. Accordingly, it was appropriate that the speaker at the water industry luncheon, Mr. Frank E. Clarke, should be an expert in the field of industrial water at the U. S. Naval Engineering Experiment Station.

Mr. Clarke's paper, "Old Wine in New Bottles—A New Look at the Substance Water," contained many new ideas about water which showed that this "commonplace" substance is destined to become the most important of our resources.

With the aid of colored charts, Mr. Clarke presented the most modern concepts of the structure of the water molecule, starting with the probable structure of the basic components—hydrogen and oxygen atoms. Including possible combinations of ordinary hydrogen, deuterium, or tritium with oxygen isotopes having atomic weights of 8, 9, 10, or even 11, Mr. Clarke said that at least 18 different varieties of water molecules have been shown to exist, even without counting any of the compounds of the short-lived oxygen-19 (less than 1 min half life). A startling concept of the water molecule was presented on the basis of "evidence that each body of water, even the ocean, is a single gigantic molecule or lattice, which might be written $(H_2O)_n$."

Clarke

Recent submarine explorations under the polar ice cap have disclosed the surprising fact that large amounts of fresh water are to be found in layers 10 to 12 ft thick under the ice. These layers presumably have resulted from the self-desalting of sea water by fractional crystallization and stratification. The separation between fresh water and sea water is so sharp that objects of proper specific gravity will sink through the fresh layer and stop abruptly at the surface of the salt water.

Striking differences between the different kinds of water were brought out. For example, heavy water (deuterium oxide) will not quench thirst, will not support plant life, but is useful as a neutron moderator in fission reactions to slow up neutrons to the optimum velocity for production of fission effects.

New and potential uses of water were discussed. Now that submarines can remain under the sea for very long periods, the water itself is desalted and then electrolyzed to provide oxygen for breathing. Ocean water is a storehouse of minerals, more and more of which will ultimately be found to be economically recoverable. The most striking prospective use of all was described as the possibility of separating from water the traces of deuterium and tritium and then using them in a controlled fusion process that would result in the greatest potential energy supply to be found in any materials in or on the earth.

Cement and Concrete

A better understanding of the hyperbolic paraboloid, or more simply the umbrella type of concrete shell construction, was gained at the cement and concrete industry luncheon.

Felix Candela, of Mexico City, one of the leading proponents of reinforced-concrete shell structures, was the speaker. He presented a highly technical subject in a refreshing and informative way. His statement that he did not need good concrete in these structures was provocative. The stress relationships and the abundant use of reinforcing steel reduce the need for high-strength concrete. The hyperbolic paraboloids provide an answer to difficult site problems, and of all the shapes given to a shell type of structure they are the easiest and most practical to build.

Candela

Mr. Candela, as President of a firm established in Mexico City in 1950, has designed and built more than 300 shell structures in that city alone, in addition to acting as a consultant for similar projects in South and Central America and in the United States.

Symposia Highlights

Technical Sessions

The week-long meeting in San Francisco included technical sessions on 25 different topics, at which about 230 papers were presented—the largest number ever presented at any ASTM national meeting. Many of these papers will be published in one form or another by the Society. Following is a quick glance at the high points.

Metals

Newer Metals

The demands for metals in the new environments of nuclear radiation, extreme temperatures, and extreme stress conditions, coupled with the need for high reliability in these applications has pushed development of the so-called "newer metals." The symposium on newer metals was held to gather information that ASTM could use in writing specifications for these metals.

Two types of data are required to rate the newer metals and their alloys: accurate base-line data obtained in the absence of all possible contamination, and reliable strength data obtained in the actual service environment. Westinghouse Electric Corp. described a universal high-temperature testing machine for vacuum or controlled atmospheres, designed for either constant strain-rate testing or for stress-rupture testing at constant load. Capacities: maximum test temperature of 3000 C, maximum load of 5000 lb, and head motion from 0.002 to 2 in. per hr.

Other papers described the mechanical properties of molybdenum and molybdenum-alloy sheet (Climax Molybdenum Co.), creep properties of beryl-

lium (Brush Beryllium Co.), fabrication procedures for columbium and tantalum (Universal-Cyclops Steel Corp.), and high-temperature mechanical properties of tantalum (Battelle Memorial Institute and The Martin Co.). Other metals discussed included the platinum group (ruthenium, rhodium, palladium, iridium, and platinum), zirconium and its alloys, yttrium and its alloys, chromium, tungsten, and lithium.

ASTM task groups are working under ASTM Committee B-2 on most of these metals. Some are collecting data for the time when an industrywide specification can be written. Others are actively engaged in drafting ASTM specifications for some of these newer metals.

Construction Materials

Concrete Admixtures

The large number of admixtures for concrete now being manufactured for a variety of purposes has led to misuse, with resulting bad effects upon the concrete itself. Several speakers at the symposium in San Francisco emphasized that admixtures had a very definite place in concrete construction when correctly used, particularly in the right amounts.

Four categories of admixtures were discussed: (1) lignosulfonic acids and their salts, (2) modifications and derivatives of lignosulfonic acids and their salts, (3) hydroxylated carboxylic acids and their salts, and (4) modifications and derivatives of hydroxylated carboxylic acids and their salts. In each, the primary component has both water-reducing and set-retarding properties which may be modified by the addition of other components. Data were presented to show the effect of admixtures on properties of plastic concrete such as water reduction, retardation, air entrainment, bleeding, and slump loss. The effects on hardened concrete included some increase in strength at 28 days, with a high rate of strength gain at 3 and 7 days; a substantially lower permeability to water under pressure; no appreciable reduction in volume change; some improvement in resistance to freezing and thawing; and a modest improvement in resistance to sulfate attack. It was stressed that the quantity of admixture added must be accurately measured for uniform results.

Road and Paving Materials

Of the several properties of paving asphalts that are of concern to the engineer, the most important is durability. As part of a program to determine performance under field conditions, the California Division of Highways introduced specifications for paving grade asphalts, and at the same time initiated the Zaca-Wigmore experimental asphalt test project. Ten different asphalts were placed on this major construction project. All of the asphalts were produced in California except one which was produced in Arkansas. The wealth of test information from this project was released for the first time in three papers at the San Francisco symposium. Two of the papers were presented by representatives of the California Division of Highways, F. N. Hveem, Ernst Zube, and J. Skog. W. C. Simpson, T. K. Miles, and R. L. Griffin,

Paul Garin, chairman of the General Committee on Arrangements, and President LaQue pause for a moment during their busy schedule to discuss the progress of the meeting.

Shell Development Co., discussed the correlation of the microfilm durability test with field hardening observed in the project. The authors from the California Division of Highways concluded that the performance of the Zaca-Wigmore test road to date clearly shows that asphalts produced from different crude oil sources and methods of production can have various degrees of durability under equivalent conditions of traffic and climate. The cooperative test series confirmed the continued need for study of the variables involved in the test. The microfilm durability test gave results showing good agreement in the progressive hardening of the asphalts in the road during a three-year period with the increases in viscosity found in the test. It was also noted that pavements with high void content hardened more rapidly than those with low void content, and that hardening of asphalts by loss of volatiles can be controlled by selecting crude oil sources or applying distillation and blending techniques so as to keep the 10-per-cent distillation point at or above 400 C, converted to atmospheric pressure.

Carl L. Monismith of the University of California, Berkeley, reported on an investigation of the effect of temperature on the flexibility characteristics of asphalt paving mixtures. Results seemed to justify the basic philosophy of asphaltic design; that is, one should include in the mixture as much asphalt as possible to insure durability and flexibility but not so much that load-carrying ability is reduced.

Fritz S. Rostler and Richard M. White reported data to show that chemical composition of asphalts is better defined by a precipitation method than by analytical procedures based on solution or adsorption equilibria. They also reported that physical (including rheological) properties of asphalts and changes of these properties during weathering can be correlated with changes in chemical composition.

Degradation of mineral aggregates, particularly in base courses under flexible paving mats, is a natural process that results from the kneading action of moving wheel loads, according to Martin Ekse and Henry C. Morris of the University of Washington. Over a period of time, heavy traffic tends to produce not only a progressively finer general aggregate grading than was initially placed in the base course, but also an excess of fine material in the particle-size range of silt and bordering on that of clay. The results of such degradation of base course aggregates are reduction of angularity and interlock of the coarser particles, and some "lubrication" of the coarser particles by increasing amounts of fine material distributed through the aggregate under moist conditions. The net effect is to reduce the stability of the base course. The authors attempted to establish an effective and practical test to evaluate this tendency of a mineral aggregate.

Wood in Structures

Timber is one of our oldest engineering materials, although its efficiency as a structural material has been limited by the development of fastenings. Several of the papers at the San Francisco symposium illustrated the increased strength now obtainable from laminated wood beams used with new types of timber connectors. This has placed timber in the same category as steel and concrete, requiring the careful application of engineering skills to make full, safe, economical use of the potentialities of timber. Laminated structural units of great size are being produced and used today. Efficient arch shapes in which the grain of the wood follows the line of principal stress can now be obtained for spans and shapes not dreamed of before.

Walter Ebeling, of the University of California, pointed out that the annual depreciation of property in Southern California resulting from attacks of termites, is estimated to be 20 to 25 million dollars. This ever-present and increasing problem has been greatly relieved by the Structural Pest Control Act. Mr. Ebeling pointed out that no method

of construction or treatment is an absolute guarantee against infestation by subterranean termites. However, measures can be taken before, during, and after construction to decrease the possibility of infestation. Such measures as the preconstruction treatment of soil with chemicals, the use of chemically treated wood, and the use of special types of construction were described. Methods used for controlling dry wood termite infestations are fumigation, the "drill and treat" method, the use of pentachlorophenol emulsion, and the use of sorptive dust. Dampwood termites are largely controlled by the elimination of the sources of moisture.

The Wood Pole Research Program, initiated in 1953 under the sponsorship of the ASTM and recently completed at the Forest Products Laboratory, Madison, Wisc., was described by E. C. O. Erickson and L. W. Wood. This extensive investigation has produced valuable information on (1) strengths of five species of untreated and preservative-treated full-size poles and matching small, clear specimens; (2) relations between the strength of poles and the strength of clear wood; (3) factors affecting strength; and (4) comparisons of two standard methods for testing full-size poles.

Another paper described the use of wood poles in various types of building construction. During the past ten years, a large number of industrial buildings have been erected, supported by pressure-treated round timber poles.

Treated Wood for Marine Use

With our "astronautical" engineers so much in the limelight as they spend billions to reach the stars, we often forget the dedicated men and women working with equal diligence to build, to safeguard, and, with small budgets, to conserve billions of dollars worth of structures we already have. Typical are the harbor engineers who, in the Symposium on Treated Wood for Marine Use reported their progress in devising tests, analyzing materials, and restoring or prolonging the life of waterfront structures against the attack of voracious little creatures with melodious names—Limnoria lignorum, Martesia, Xylotrya gouldi, Teredo teredo.

The use of treated wood panels is a satisfactory method for rapidly screening wood preservatives. This was reported by Thorndyke Roe, Jr., and Harry Hochman, U. S. Naval Civil Engineering Laboratory, Port Hueneme, Calif. Work in the same laboratory on a procedure for evaluating the toxicity of chemical agents to marine borers was reported in a paper by Harold Vind and Mr. Hochman. The test animals were collected from the intertidal zone of old piling—a task that would bring joy to the heart of any small boy who likes to play with bugs.

Dissatisfied with the reliability of wooden piling inspection from the water surface only, the Los Angeles Harbor Department has resorted to submarine inspection by divers. A comparison of results was presented by E. V. Dockweiler and H. E. Stover, Chief Harbor Engineer and Assistant Testing Engineer, respectively, of the Los Angeles Harbor Department.

An ingenious method of prolonging the life of wooden marine piling by wrapping with pliable sheet barrier material such as rubber, neoprene, poly(vinyl chloride), or similar material was described in a paper by C. M. Wakeman and L. L. Whitneck of the Los Angeles Harbor Department. Other barriers described were made of vitrified pipe, concrete, and corrosion-resistant metals.

Bituminous Materials

Roofing asphalts and pitches are subjected to very severe exposure conditions. Light, heat, and oxygen produce progressive embrittlement. Service stresses cause surface attrition and eventually widespread cracking. These conditions were reviewed by A. B. Brown and S. W. Sparks, Standard Oil Co. of Indiana. Composition, sensitivity to chemical change, and nature of the mechanical composition were discussed as areas of fundamental interest.

Accelerated weathering tests provide a guide for evaluating weatherability of asphalts under service conditions according to E. W. Mertens and S. H. Greenfield, California Research Corp. A significant point made was that weathering characteristics cannot be associated with the crude oil source alone as fluxing stocks, catalysts, fillers, and added materials can definitely affect the weatherability as well.

Raw materials and production methods for coal tar flat roof pitch were discussed by M. D. Chamberlain, co-author with W. F. Fair, Jr., both with Koppers Co. Chemical composition and physical properties were described which are significant in contributing to good performance.

What is an industrial pitch? J. W. Donegan, Allied Chemical Corp., as co-author with C. V. Pittman, Koppers Co., attempted to describe this class of bituminous material. This material is primarily used by industry in the manufacture of other products. Rigid requirements are imposed. Among the uses are in bitumized fiber pipe, as plasticizers and as binder pitches.

The advantages of using glass fiber in bituminous felt roofing was described very well by J. G. Hayes, Owens-Corning Fiberglas Corp. Glass fibers as reinforcement overcome the natural deficiency of bituminous materials in low mechanical strength and plastic flow.

Bituminous material as grouts, mastics, and cold applied cements presents an interesting field of usage, as described by F. H. Haney, co-author with W. L. Butterfield, Flinkote Co.

The manufacture and application of asphalt roofing was covered by L. C. Haack, Certain-teed Products Corp.

Symposia Highlights

Masonry Materials

The fact that efflorescence is a complex phenomenon and that differences of opinion therefore exist on how to interpret this condition was stressed by P. L. Rogers, Riverton Lime and Stone Co. Through the work of ASTM Committee C-12 on Mortars for Unit Masonry, based upon a background of research by others, a proposed method of test could now be considered by which specification limits could be set that would be tolerant enough to take care of some of the uncertainties that still exist.

Reduction of 35 per cent or more in the weight of structural clay masonry units appears to be practicable by production methods. Research and testing data presented by Paul V. Johnson and W. K. Soderstrum, Structural Clay Products Research Foundation, indicated that the interrelationships of certain physical properties of lightweight units might differ from those in units now manufactured.

The need for a field test of masonry mortar and grout was emphasized by Norman W. Kelch, Associated Brick Manufacturers of Southern California. A simple method for making field-test specimens of mortar and grout for reinforced grouted brick masonry was described. This method is now in use in Southern California and recognized by the building code authorities.

Testing Building Constructions

The use of diaphragms in buildings and other structures has increased during the past ten years as a result of the introduction of many new materials and modifications of existing materials. This is true on the West Coast, where the diaphragm is an important element in resisting forces induced by earthquake shock or wind. Two speakers at the San Francisco symposium dealt with this subject: Robert D. Cousineau, Converse Foundation Engineering Co.; and S. B. Barnes, S. B. Barnes and Associates. Full-scale tests of large diaphragms were discussed, and it was concluded that coordination is needed not only in developing standard test methods but in establishing working values for design.

West Coast Meeting

John J. Holstein, consulting structural engineer, presented the results of lateral shear tests performed on a light-gage steel building. The testing of reinforced grouted brick masonry as well as hollow concrete masonry wall panels to determine diagonal tension and shear values was described by N. W. Kelch, Brick Manufacturers' Association of Southern California, with the aid of a colored movie. These panels were erected and tested under the auspices of the University of California for the State Division of Architecture.

Sandwich Structures

Structural sandwich constructions have been used in considerable volume both in the aircraft as well as the building construction fields. Because these new materials and constructions lack a long history of service and performance, a number of testing programs have been established to study the effects of environment and service conditions on sandwich construction.

Laboratory tests were reviewed by A. C. Marshall, Hexcel Products, Inc., on many commonly used types of glass-fabric-plastic core materials. Mr. Marshall felt that correlation had been achieved by the laboratory accelerated and service degradation tests. R. F. Zemer, Douglas Aircraft Co., summarized the first of three exposure projects of a variety of types of sandwich construction and core materials at ASTM test sites at Kure Beach, N. C., and State College, Pa. This was the first presentation of exposure tests programs sponsored by ASTM Committee C-19 on Structural Sandwich Constructions.

An investigation of adequacy of adhesive bonding after field exposure in the Hawk missile was reviewed by A. J. Tuckerman, Northrup Corp. Mr. Tuckerman stated that laboratory exposures are a valuable tool in evaluating adhesives, but that field service data are required to support the laboratory data. The durability of a bonded repair system for aluminum honeycomb structures was given a severe test in the exposure of panels in the Panama Canal Zone for periods up to two years. J. P. Reese, Martin Co., reported that there was no evidence of deterioration in the system using an epoxy adhesive.

Temperature rise in structures due to solar heating was described, and suggestions for design of sandwich construction exposed to solar radiation were offered by Don K. Rider, Bell Telephone Laboratories. The fact that structurally adequate panels with expanded polystyrene core material can be designed and used was shown by E. A. Edberg, Koppers Co., Inc. This conclusion was based on results from tests of a pilot structure using panels faced with many combinations of facing materials.

Organic Materials

Paint

Interior use of latex paints, even on masonry, has proved so successful that sales are now counted in tens of millions of gallons each year. On exterior wood surfaces, however, failures have developed within the first year or two. Roy C. Simon, The Dow Chemical Co., described studies made to find the causes of failure in outdoor applications. Exposures over new wood and over oil-base house paint primers showed that the start of latex paint film failure and the extent of failure relate to the type of wood, the type of graining in the wood, and to the type of latex system. The testing program evaluated these factors to help in the development of a successful latex system for wood, and latex paints have now been designed to meet the needs revealed by the testing program.

In a paper on "Lightfastness Testing of Pigment Colors," W. F. Spengeman and G. Wormald, E. I. du Pont de Nemours & Co., Inc., reported lightfastness correlation data on a variety of pigment colors of markedly different chemical constitution dispersed in a single vehicle system at a constant pigment volume concentration of 15 per cent. The vehicle was a good quality air drying, medium length, soya bean oil modified alkyd. The finishes were sprayed to complete hiding on primed aluminum panels and exposed at an angle of 45 degrees facing south in Florida and in Delaware. Panels were also exposed in an Atlas Fade-Ometer (type FDA-R) and in an Accelerated Weathering Unit (X-1-A). Results from Florida and Delaware were generally in qualitative agreement, although color changes in Florida proceeded at a faster rate. These tests show that the relative colorfastness of pigments of the same chemical nature can be reliably compared in both wet and dry accelerated exposure devices (Fade-Ometer and AWU). The approximate colorfastness on exterior exposure of a pigment, or the relative colorfastness of two or more pigments which differ in chemical nature, cannot usually be reliably predicted from accelerated exposures except when correlation has been previously developed and corresponding "speed-up-factors" applied. Also, unless modified, the accelerating devices cannot duplicate the influence of abnormal atmospheric conditions, for example chemical impurities.

Hydraulic Fluids

Hydraulic fluids in aero-space vehicles are affected by: low pressure, radiation, ozone, dissociated gases, aurorae, and temperature extremes. The low pressures encountered at high altitudes require that hydraulic fluids in contact with the atmosphere have low vapor pressures. Otherwise, the residues from evaporation would soon ruin any external dynamic seals. Also, the scarcity of oxygen at high altitude drastically raises the coefficient of friction. Solar radiation, by itself, does not appear to be damaging, but cosmic rays may create severe problems. Ozone concentration varies with altitude, and both molecular and atomic oxygen can react strongly with materials at high altitudes. On the other side of the balance sheet, the attributes which recommend hydraulics for space flight are: great power, small volume, and accurate control. In his paper, "Is Hydraulics Out of This World?," George R. Keller, Autonetics, a Division of North American Aviation, Inc., stated that "the specific jobs which hydraulic power will be called upon to perform are well within the capabilities of today's technology. The problems really center about the reliability of hydraulics in this new environment."

Petroleum-derived hydraulic fluids transmit power and lubricate system pumps quite efficiently, but they present a serious fire hazard where equipment failure might result in the fluid coming in contact with an ignition

The Apparatus Exhibit drew many interested visitors to the wide variety of the latest equipment.

source. To overcome such hazards, fire-resistant hydraulic fluids are being developed. C. E. Francis and H. E. Sipple, of Shell Oil Co., described the fire resistance of an emulsion-type fluid in some detail. They gave the results of empirical flammability tests and reviewed a number of incidents in commercial installations involving equipment failures that exposed the emulsion to various ignition sources.

In present-day automobiles there are many accessories that have their own hydraulic system, such as power steering, power brakes, convertible tops. Present practice is to add a new actuating mechanism for each device added. A central hydraulic system, analogous to the conventional automotive electrical system, offers the possibility of operating a number of devices from one central power source. This new development was described in the paper on "Automotive Central Hydraulic Systems and Their Fluid Requirements," by T. H. Risk, Ford Motor Co. Connecting all of the various devices to one power source should reduce complexity and cost. This should mean easier installation, lower maintenance costs, and more trouble-free operation.

Reinforced Plastics

Plastics materials reinforced with glass-fiber mats and fabrics are finding increasing use in structures. The problems of defining the properties of these materials for military applications are no less acute today than were similar problems of specifying war materials in the day of the longbow. H. A. Perry, of Naval Ordnance Laboratory, speaking at the reinforced-plastics symposium in San Francisco, pointed out that a supplier of seasoned wood for longbows for a medieval army might be deprived of his head if the quality of the product were found inferior. While such drastic methods of quality control are in little use today, there are difficult problems of describing and evaluating the properties of reinforced plastics for procurement purposes.

Pointing to one application where reinforced plastics are proving their worth, George Epstein, of Aerojet General, described a test cell for measuring permeability of reinforced plastics to gases at pressures as high as several thousand psi and at high temperatures. This test is applied to filament-wound pressure vessels in which failure in the test is caused by progressive gas permeation with successive delamination of the plies during cycling and relaxation of adjacent plies. The test method has also been useful in evaluating the effectiveness of sealant materials to be used in reducing the permeability of filament-wound pressure vessels.

Present ASTM methods for evaluating mechanical properties of plastics have not been found satisfactory for determining properties of filament-wound reinforced plastics. William McCarthy, of The Brunswick-Balke-Collender Co., told the symposium that he had devised some modified mechanical tests especially adapted to specimens cut from filament-wound reinforced plastics. He described tests and presented data on methods for tensile, compressive, and flexural strength, as well as a bearing test and several different varieties of shear. A special shape proposed by Mr. McCarthy for evaluating filament-wound materials is a cylinder from which both circular ring specimens and straight specimens are cut. By testing these two types of specimens Mr. McCarthy was able to obtain mechanical property values in both the hoopwise and lengthwise directions corresponding to the principal directions of loading in a radome or similar structure.

ASTM President Frank L. LaQue (*left*) and Felix Candela, Mexico City architect, compare notes prior to the Cement and Concrete Industry Luncheon, at which Sr. Candela was the speaker.

Adhesion and Adhesives

While the word "glue" has been yielding to the more elegant term "adhesive" in past years, the uses to which adhesives are being put have been multiplying rapidly. Twenty years ago, there was no commercial production of metal-to-metal adhesive-bonded structures. Today, building spandrels, aircraft fuselages, and truck trailers are among the growing list of items being glued together.

Much of this progress is due to a greater understanding of the molecular physics of the adhesive mechanism. Samuel Muchnick opened the San Francisco symposium with a review of the theoretical and experimental knowledge of the fundamentals of adhesion.

Experimental work in Germany on metal-to-metal adhesives was reviewed by K. F. Hahn. The European aircraft industry has put heat-curing resins to general use. German research, however, has also covered room-temperature-curing adhesives, which are especially valuable for repairs in the field. Since work in the United States is largely on heat-curing adhesives, the German work on room-temperature-curing adhesives is of much interest to us.

Most of the metal-to-metal bonding adhesives used today are phenolic or epoxy-modified phenolic types. These, however, will withstand only short-time exposure to temperatures above 500 to 1000 F. Prolonged high temperatures break down the polymer structure and drastically lower strength. E. C. Janis described research in which an inorganic component (most satisfactory to date: arsenic pentoxide) was added to the organic adhesive to provide thermal resistance. Results definitely indicate that organic-inorganic adhesive systems are one answer to the thermal resistance problem.

High-temperature resistances of five ceramic adhesives were evaluated by L. E. Gates and W. E. Lent. The inorganic adhesives were prepared as ceramic frits and applied to stainless steel, the material being considered for wings and control surfaces of advanced missiles. Data from tests at 800 and 1200 F show great promise for this type of adhesive.

Symposia Highlights

Electrical and Electronic Materials

Electrical Insulating Materials

The service environment of insulating oils is unique among those for refined petroleum products due to the type and variety of substances with which it comes in contact. Service conditions for insulated oils have become more severe in recent years because electrical components are operating at higher loads and therefore higher temperatures. These problems have resulted in the need for rare crude oils, bench-test performance criteria, and more field performance data. N. W. Furby and F. J. Hanly, California Research Corp., showed that inhibited oils, much more suitable than those now used, have been developed and could be made available commercially.

The encapsulation of electric motor windings is gaining widespread industrial acceptance. Its advantages are: high resistance to chemicals, moisture, and fungus; prevention of movement and vibration; and exclusion of grit and dirt from the windings. Encapsulation has markedly increased service life in severe environments. Epoxy resin formulations designed for stator

encapsulation are characterized by good strength, excellent adhesion, and excellent electrical and chemical resistance properties. Henry Less, of Epoxylite Corp., presented results of investigations of four suggested test methods for evaluating the compatibility of magnet wire and epoxy encapsulating resins: field tests of motors, chemical resistance tests, motorette tests, and twisted-pair tests.

Materials in the Electronics Industry

Representatives of four ASTM committees serving the electronics industry discussed ASTM contributions toward solving some of the industry's materials problems. J. H. Koenig described work on electronic ceramics in progress in Committee C-21 on Ceramic Whitewares. Dr. Koenig, who is also chairman of the Electronics Division of the American Ceramic Society, urged the establishment in ASTM of a committee on electronic ceramics to emphasize the importance of this fast-growing group of electronic materials. Electronic ceramics, which include dielectrics, insulators, piezoelectrics, semiconductors, magnetics, and composites, have made possible new designs and improved performance of many electronic components and systems.

The Society's work on magnetic materials, insulation, printed wiring, and electron-tube materials was described by others, who then formed a panel to answer questions from the floor. Discussion was spirited and all left with a feeling that this is a desirable kind of session to have at a national meeting where ASTM work in related fields is discussed.

Water

Water and Industrial Waste Water

Industry in general, and West Coast industry in particular, is increasingly concerned with obtaining enough process and cooling water of adequate purity, and then with the further problem of disposing of the water after it is polluted by various industrial processes. Ten papers covering these problems were heard at the San Francisco symposium.

Sample topics were: the determination of radioactive materials in water, the disposal of radioactive waste waters, and the disposal of oil field brines. The latter problem has been solved by using untreated oil field waste waters of relatively low salinity for irrigation of local crops. One paper discussed the effects of various types of industrial wastes on water for irrigation. The case for municipal treatment of industrial wastes, in addition to sewage, was also presented.

Subjects of three other papers were: treatment of water for once-through reactor cooling, electric membrane (electrodialysis) demineralization of a municipal water supply, and solar distillation of saline water. Particular consideration was given in the third paper to problems encountered in connection with materials for use in solar stills.

The use of cooling towers was shown to be valuable not only in reducing the amount of water needed for cooling purposes, but also in helping to reduce pollution by industrial wastes through keeping the waste at the optimum temperature for most effective treatment—as, for instance, in activated sludge treatment of wastes from a paper products plant. Since excess temperature of waste water can be very objectionable, cooling by suitable towers can itself be an important treatment of waste water not requiring other treatment.

HOSTESS COMMITTEE FOR THE THIRD PACIFIC AREA NATIONAL MEETING.

In the Garden Court where the ladies were entertained at coffee each morning, *left to right:* Mrs. P. E. McCoy, Mrs. P. V. Garin, Mrs. E. V. Noe, Mrs. G. J. Grieve, and Mrs. H. P. Hoopes. Mrs. Roy Henning could not be present.

Radiation and Nuclear Energy

Nuclear Problems

Communication is the key to ASTM committee work on nuclear standards. Many of those faced with the need for nuclear standards are not aware of the scope of ASTM standardization activity in this field. Many acquainted with ASTM standards do not know how to bring their need for nuclear standards to the attention of the proper ASTM group, nor do they know the rules of ASTM committee procedure in drafting and approving standards. Conversely, the ASTM committee personnel cannot give full consideration to a proposed project unless it is properly presented and technical people acquainted with the problems are available to participate in the committee work.

These problems were aired at the second forum sponsored by the ASTM Special Administrative Committee on Nuclear Problems. Copies of the discussions at the first forum, held in Atlantic City in June, have been made available to industry. The function of this special committee is to establish communications between reactor technologists and the ASTM technical committees. It was pointed out at San Francisco that perhaps too much emphasis has been placed on finding problems and forwarding them to the appropriate ASTM committees for consideration. Another approach would be for members of the committee or the ASTM Staff to describe ASTM technical committees and procedures to groups of reactor technologists and to recommend that the latter bring problems directly to the ASTM technical committees, become members, and participate in the committee work.

Another communications problem has to do with advising the reactor technologist concerning present activities

in the ASTM technical committees on materials for reactors. Several of those present were amazed at the activities outlined in the transcript of the first ASTM Forum on Nuclear Problems. This further pinpointed difficulties in communication, since the technical press had been notified months in advance of the second forum that copies of the transcript of the first forum would be furnished to anyone requesting them from ASTM Headquarters.

One specific group of reactor technologists is now organized within the ASTM committee structure. In Committee E-10 on Radioisotopes and Radiation Effects, Subcommittee II on Radiation Induced Changes in Materials has repeatedly emphasized its readiness to aid other ASTM committees in problems of reactor materials. This subcommittee has also organized a series of task groups to canvass the reactor industry on material problems. When these problems are definitely established, it is planned to have representatives attend ASTM technical committee meetings and help in their consideration of specific tasks. Chairman of this activity is J. V. Alger, Westinghouse Electric Corp., Bettis Plant, Pittsburgh, Pa.

Radioisotope Test Methods

With the availability and knowledge of radioisotopes increasing every day in American industry, it is only a matter of time before ASTM adopts standard test methods for their use. This symposium was held to focus attention on several procedures using radioisotopes that might be adopted as ASTM standards.

Much discussion centered on a program of radioactive ring wear testing in diesel locomotives sponsored jointly by the Southern Pacific Co., the Standard Oil Co. of California, and the California Research Corp. Irradiated piston rings were installed in the engines of several Southern Pacific diesel locomotives. The radioactivity of the lubricating oil due to ring wear was measured in a counting well with Geiger-Muller tubes. This procedure has proved to be an excellent tool for investigating a wide variety of factors that influence ring wear in diesel locomotives.

J. L. Kuranz, Nuclear-Chicago Corp., described a portable instrument for measuring soil moisture and density, developed as the result of a contract with the Corps of Engineers. With this instrument, individual determinations can be obtained in two minutes or less; the accuracy is equal to or better than with conventional methods, and the cost is economical. Mr. Kuranz has drafted a proposed ASTM test method covering these procedures.

The lack of progress in agreeing on a standard laboratory test for laundry detergency performance was attributed to the general use of carbon blacks as standard soils and limitations on measurement methods, in a paper by the Wyandotte Chemicals Corp. It was suggested that a calcium-45 tagged clay dispersed in lubricating oil be used as the test soil, since evaluations with this soil appear to be in better general accord with practical observations than do those with carbon-black soil.

One major problem in the cement industry is the chemical analysis for magnesium. The standard magnesium analysis takes 28 hr, most of which is needed for digestion, filtration, ignition, and weighing. The portland-cement industry, which depends on chemical analysis for quality control, needs a faster test. Battelle Memorial Institute has developed a procedure using the basic method but labeling the ammonium monohydrogen phosphate with phosphorus-32. This enables one to make a direct determination of the amount of precipitate formed without carrying out digestion, filtration, ignition, and weighing. Using this procedure one can analyze for magnesium in less than an hour.

Post-Irradiation Effects

Plastics and other polymeric materials that have been exposed to high-energy radiation are generally alive with highly reactive areas in their molecular backbone. These reactive sites, called "trapped free radicals," cause both chemical and physical changes which continue after irradiation. In order to study these effects of radiation on plastics by evaluating them before and after irradiation, one must take into account this induced reactivity and instability of properties, both in evaluating the effects and in considering the application to which the irradiated materials might be put. This was brought out by D. S. Ballantine of Brookhaven National Laboratory in discussing the significance to ASTM of post-irradiation effects in irradiated materials.

L. A. Wall, of the National Bureau of Standards, described methods of detecting and identifying free radicals using electron spin resonance. Dr. Wall described studies with polystyrene and related polymers. While certain radical structures have been identified, he said, full understanding and interpretation of the ESR spectra and their behavior with temperature have not yet been achieved.

Radiation effects on dielectric properties of silicones, particularly changes following irradiation, were discussed by C. G. Currin of Dow Corning Corp. He subjected several types of silicones to a three- to five-megarad dose using a cobalt-60 source at room temperature and at 150 C over a period of 20 hr. There was a relatively small subsequent change in dielectric constant and dissipation factor. Post-irradiation effects were small and usually lasted less than an hour. Mr. Currin recommended that for evaluating property changes due to radiation, the properties should be measured at least one hour and preferably ten hours after the radiation exposure because of the observable changes immediately following exposure.

Radiation Effects and Dosimetry

Dosimetry, one definition of which is "any measurement of a nuclear radiation field or the absorption of its energy in matter," was the subject of seven of the fourteen papers presented at this symposium. One of the papers was devoted to dosimetry nomenclature, another covered standardization of terminology for gamma and electron beam radiation sources.

The papers devoted to dosimetry covered gamma dosimetry, techniques for measuring reactor neutron spectra, reactor monitoring by calorimetry, removal dose as a measure of radiation, dosimetry nomenclature in the United States, dosimetry in Europe and the USSR, and uranium burnup, in which the measurement of radiation dose is one problem. The coverage of recent developments in gamma dosimetry was especially complete, one of the techniques discussed being the Fricke method recently issued by the Society as tentative. In addition to the measurement of the amounts and intensities of radiation under given radiation exposure conditions, the discussions covered methods of measuring and even predicting neutron flux and neutron energy spectra in and around reactors. The paper on monitoring mixed radiation fields by calorimetry described apparatus and procedures for measuring total radiation and also separately the gamma radiation in calorimeters, which convert the radiation into heat energy for measurement.

Radiation effects on materials were considered in six papers covering both organic and metallic materials, with particular attention to plastics and to reactor pressure-vessel steels. Also covered was the question of radiation effects in unmanned nuclear-propelled vehicles, where high radiation intensities of relatively short duration may be required. A fundamental discussion of the atomistic interpretation of radiation effects in metals was presented in another paper, which included a list of fifty references.

West Coast Meeting

Ceramics in Nuclear Energy

Rapid developments in the past few years in the technology of refractory oxides indicate that these materials will come into much wider use in the next few years, not only in the reactor industry, but wherever strength and oxidation resistance at high temperature are required.

As a moderator and structural material for high-temperature nuclear reactors, beryllium oxide shows many outstanding advantages over other materials. J. E. Hove emphasized the advances being made in current research programs. In recent work, for example, beryllium oxide has achieved a strength of nearly 30,000 psi at 2200 F.

In reactors in which the fuel consists of pellets of ceramic material enclosed in a metallic cladding, much closer dimensional tolerances than those usually acceptable to the ceramic industry are required. The refinements in ceramic techniques necessary to improve the tolerances on dry-pressed ceramic fuel pellets were discussed by F. J. Harting, and a formula to predict fired density and dimensions based on the unfired pellet was compared with experimental results.

L. Wisnyi and K. Taylor used cold pressing and sintering techniques to fabricate urania-alumina fuel elements and boron carbide burnable poisons. Following a discussion of their techniques of producing strip specimens, it was concluded that the material is at present satisfactory, but the urania-alumina fuel strips can be improved. Their strength and corrosion resistance can be improved by higher sintering temperatures, if dimensional tolerances and density can be held within limits. With boron carbide, the high sintering temperature of 2150 C is the most important factor contributing to its high strength and very good corrosion resistance.

K. M. Taylor and C. H. McMurtz described a spherical graphite matrix element fueled with uranium dicarbide and clad with an impermeable layer of silicon carbide, for use in a pebble-bed, gas-cooled reactor. The primary function of the silicon carbide cladding is to retain fission products within the element. The work has shown that the present element is satisfactory in most respects, except for impact strength.

Recent work on the hot extrusion of a powder mixture of U_3O_8 and aluminum, contained in an aluminum can, into a long aluminum-clad shape from which individual fuel elements are sheared, was reported by R. A. Noland, D. E. Walker, and L. C. Hymes. There is a high conversion yield from the billets and the reproducibility is excellent. The process has been successfully used in two small reactors.

Testing and Analysis

Spectroscopy

The analysis of portland cement by X-ray emission spectroscopy, application of X-ray spectroscopy to geochemistry, determination of tetraethyllead by flame photometry, and the analysis of radioactive materials, were among the topics covered in the 25 papers presented in the symposium on spectroscopy. All current techniques in emission and absorption spectroscopy were discussed, including the newer magnetic resonance techniques and methods for atomic spectroscopy.

The growing importance of X-ray spectroscopy, both emission and fluorescence, was considered in four of the papers, one of which provided an interesting look into the future of X-ray fluorescence instrumentation.

Recent developments in closely related techniques now growing rapidly in importance—nuclear magnetic resonance spectroscopy and electron paramagnetic resonance spectroscopy—were presented in four of the papers. New developments in circuits that propagate slowly traveling waves, as in masers and similar applications, were presented in addition to consideration of general principles and applications of magnetic resonance spectroscopy.

Air Pollution Control

The timeliness of the symposium on air pollution control at the West Coast Meeting was brought home forcibly when, during the morning session of the symposium, a smog condition developed in the San Francisco Bay Area of sufficient seriousness to require the author of the first symposium paper to return to his office at the headquarters of the Bay Area Pollution Control District. The paper had discussed those geographical and climatic conditions which constitute an air pollution potential along the California coast. Here, atmospheric temperature inversions at low altitudes are prevalent, and horizontal wind movements often are not adequate to dilute and remove any large amounts of pollutants.

Other papers covered the making of wind and weather summaries for chemical plant design and air pollution control, the use of fluorescent dyes as airborne tracer materials, the determination of gaseous and particulate inorganic fluorides in the atmosphere, and the colorimetric determination of formaldehyde and methanol from combustion sources.

The use of fluorescent dyes as tracers was shown to provide a rapid and extremely sensitive method for determining the rate and extent of distribution of an airborne industrial effluent, with distinct advantages over the use of a fluorescent pigment or finely divided antimony oxide.

The paper on fluorides considered the collection and analysis of samples of gaseous and particulate inorganic fluorides from the atmosphere, with special attention to sampling in such a way as to permit the determination of the separate amounts present in the gaseous and particulate forms. In agricultural problems in particular, the form in which the fluorides are present has a major effect. Small variations in sampling location near vegetation were shown to have surprisingly large effects on the concentrations of fluorides found.

With automobiles proving to be one of the more serious sources of atmospheric pollution—particularly in contributing to the type of smog that irritates the eyes and respiratory system—the concluding portion of the symposium was devoted to a paper on a new type of engine, still in the experimental stage, that is claimed to greatly reduce the proportion of unburned hydrocarbons in the engine's exhaust. A panel discussion covered the contributions of current automobile engines to air pollution, compared them with what could be expected from the new engine, and also discussed other ways (such as afterburners) of reducing the pollutants from automobiles.

Nondestructive Testing

The radiography of solid rocket propellant and information on the inspection of the Polaris motor were described at the Symposium on Nondestructive Testing in the Missile Industry. The paper sponsored by the Naval Ordnance Laboratory described the use of 2- to 26-Mev X-rays to measure defects in the propellant of rocket motors from 30 to 60 in. in diameter. Defects and discontinuities in the propellant affect the performance, reliability, and safety of the rocket motor. The detection of even the smallest of the voids is important in determining the relationship between void size and motor performance.

The nuclear and space technologies require stringent inspection of materials used in reactors and missiles, to a degree far greater than before. Need for this type of inspection has become the basis for interest in the radiographic characteristics of high-energy X-rays. New types of particle accelerators, capable of producing X-rays in the multi-Mev region, have been developed for practical use within the past few years. A paper from the High Voltage Engineering Corp. presented information on X-ray equipment and techniques in the 6- to 30-Mev range.

Honeycomb constructions, with their high strength-to-weight ratio and ability to interrupt crack propagation, are now widely used in missiles and high-speed aircraft. However, in order to maintain these characteristics the adhesive bonds must be secure and uniform. Ultrasonic inspection has proved to be of much help in evaluating adhesive-bonded aluminum structures. North American Aviation, Inc. described its experiences with these structures; representatives from Convair, Aerojet General, Martin Co., and McDonald Aircraft joined in the discussion.

Thermal Ablation

Because of the impetus provided by the missile and space program, there is a great search under way to find suitable materials which, by the process of ablation, can offer thermal protection in such areas as nose cones and rocket exhaust housings of space vehicles. Ablation is the now familiar process whereby a surface layer of a material to be sacrificed is gradually sloughed off, and, in the process, carries away heat that would otherwise be absorbed by the structure beneath. Confronted with the problem of developing suitable materials for such uses, researchers soon decided that some means of simulating these conditions in the laboratory would be necessary. Much ingenuity has been displayed in the use of high-temperature flames, electric arcs, molten metal baths, rocket exhausts, and the like, for studying the ablation process. While a great deal of data have been collected and workable theories of the ablation process developed, still needed are qualitative yardsticks for evaluating the ablation resistance of materials.

As an indication of the need for standard tests, Herzog and Donaldson, of the U. S. Naval Ordnance Test Station, emphasized the critical need for a reliable short-time test to evaluate materials for rocket nozzles and nose-cone insulators. Without such a test, the materials engineer has found it difficult to instill confidence in the missile designer who, as a result, feels obligated to test materials in actual missile structures. Little can be learned from one-shot tests, and they are extremely time-consuming and costly.

The papers in this symposium outline a number of methods that have been devised to test ablation characteristics of materials. The published proceedings will provide a baseline for the development of standard methods so vitally needed in this important field.

Fatigue

Recent investigations by several aircraft companies have shown that jet engine noise can produce structural failures in jet aircraft. These failures, usually concentrated in the flap, wing trailing-edge, tail, and after fuselage areas, occur as sudden, large-scale skin failures and as extensive cracking during the service life of the airplane. Robert H. Vreeland, of Douglas Aircraft, described to the fatigue symposium a test procedure for obtaining basic information that can be used in the design of surfaces for resistance to this sonic fatigue. This method makes use of a jet engine mounted in a test stand which has considerable area behind it. Specimens are subjected to a noise environment in this area closely approximating that on the surface of a jet-propelled airplane. Where other tests simulate environment, this test subjects the specimens to the actual service condition.

In contrast to manned aircraft, missiles and space flight structures are subjected to a relatively small number of load cycles throughout their lives. John Padlog, of Bell Aircraft Corp., and Ivan Rottinger, of the Space Technology Laboratories, pointed out that investigations of some early missile failures traced the causes to pressurized components subjected to only a moderate number of cycles. They subjected thin-walled tubes, notched and unnotched, of type 403 stainless steel, to internal pressures to produce low-cycle fatigue failure. Fatigue strengths were also determined for notched and unnotched flat, axially loaded specimens of the same material. The unnotched tube fatigue strength was less than the unnotched flat specimen, but comparable to the axially loaded notched specimen.

"Although fatigue is universally recognized as a serious problem, efforts to combat it are largely haphazard," stated E. T. Haire, of the Martin Co. Mr. Haire described various fatigue phenomena in quantitative terms and outlined a system of procedures designed to insure uniformly adequate fatigue strengths and to maintain crack-free service structures.

These brief descriptions merely touch the fringes of the vast areas of investigation covered by the eleven papers presented at this symposium. Other subjects covered include fretting damage; crack propagation; development testing, in the design stage, of a helicopter rotor blade, and an extensive report describing the development of loading spectra for testing aircraft components and structures.

General

Standards—Changes Needed?

While ASTM work by and large is amicable and cooperative, there is no denying the fact that at times various

Symposia Highlights

groups may attempt to influence the outcome of committee work to their advantage. An illustration of such tactics in ASTM committee work was given by F. N. Hveem in commenting on ASTM standards for highway materials at the San Francisco meeting. He referred to the problem of establishing limits on the alkali content of portland cement. Of the seven-member working group, three were producers. The consumers provided exhaustive data to show a need for restricting alkali content of cements where reactive aggregates were involved. The three producer members, on the basis of limited data showing that the restriction on alkali content might not be a complete solution, voted "no," thus preventing an optional limitation on alkalis in portland cement. Mr. Hveem gave several other examples of ASTM work having been slowed to a standstill by such tactics. On the matter of test methods developed by ASTM committee activity, Mr. Hveem was highly complimentary, praising the conscientious and time-consuming work of the committees. He warned however, against any changes in the Society organization which might tend to favor or protect the interests of producer or manufacturer.

In a prepared reply to Mr. Hveem, Prof. K. B. Woods, past-president of the Society, pointed out that the work of ASTM is definitely democratic and the regulations are such that no one group can dominate the proceedings for long. ASTM procedures—democracy in action—may be somewhat less efficient than more autocratic methods but are certainly best from nearly every angle in the long run.

Commenting on the technical aspects of standards and changes needed, Prof. Joseph Marin, of the Pennsylvania State University, urged that strength testing be established on the basis of true stress-true strain. As anyone familiar with strength testing knows, present ASTM tensile strength properties are based upon original cross-sectional areas even though the cross section at fracture may be quite different.

Paul McCoy, vice-president of American Bitumuls and Asphalt Co., said that sound standards should be dynamic, because progress is tied to standards and they must be dynamic to keep pace with industrial progress—even to bring it about. He said "the increasingly rapid development of the newer materials and equipment with new and difficult demands on materials emphasizes the grave need for adequate test methods and specifications."

Materials in the Aerospace Age*

By Lieut. Gen. B. A. Schriever[1]

MATERIALS HAVE continuously proved themselves as a vital stimulus in the progressive growth of our country, both economically and militarily. Aluminum is a classical example. Aluminum aircraft were a tremendous breakthrough with respect to range and performance over their wood, fabric, and wire predecessors. From this early beginning, aluminum has become an almost indispensable material to both our civilian economy and national security.

Titanium is now in a situation comparable to that of aluminum 30 years ago. This extremely versatile material was brought to its present state of development through the expenditure of almost two billion dollars of governmental funds. It is already paying off handsomely in its contribution to national security. Supersonic fighters and bombers like the B-58 employ it for weight-saving applications where heating precludes the use of aluminum. Titanium is already beginning to find many civilian applications. The chemical industry, for example, is putting it to excellent use where severe corrosion is a problem.

Synthetic materials such as plastics and rubbers have had profound influence on both our economic and military well being. Early aeronautical applications of plastics resulted in considerable weight savings in cockpit enclosures, and plastic radomes contributed significantly to airborne radar. These early military uses of plastics led to a host of civilian applications. Even wider use of plastics can be expected as a result of the extensive research and development programs of the Defense Department and private industry. Unfortunately, plastics have tended to resist standardization both as to quality and performance. The efforts of this Society to provide the required standardization will help us to fully exploit these materials in military applications.

The German work on ersatz materials during World War I, necessitated by the British blockade, resulted in the production of the first synthetic rubber. Cut off from its source of supply of natural rubber, American industry concentrated on additional synthetic rubber development. These synthetic rubbers satisfied many essential civilian and military requirements during World War II, such as, hose, seals, and gaskets for hydraulic systems; aircraft and automotive tires; and the self-sealing fuel tank. Continued development of these "tailor-made" materials has solved many problems of our modern Air Force. For example, specially compounded synthetic rubbers were developed for jet and rocket fuel systems.

The B-58 Hustler is a major addition to the deterrent power of the United States. Its superior performance is largely due to the employment of recently developed materials and radical departure from past materials utilization practices. Its aircrew enclosure includes a newly developed, heat-resistant, transparent rubber as the interlayer material. Conventional riveting of the airframe is replaced by bonded sandwich construction. This construction is of two types: stainless steel brazed to metal honeycomb for resistance to aerodynamic and engine heating, and aluminum bonded to plastic for rigidity and efficiency. Titanium is employed strategically to provide weight savings and increased strength at elevated temperatures.

The Air Force is placing even stronger emphasis on the use of composite structures. Newly developed brazed stainless-steel sandwich construction is planned for extensive structural applications in the B-70, thereby contributing to the superior performance of this advanced weapon.

Materials developments and pioneering military uses such as these pave the way for subsequent commercial applications.

In this brief analysis of the important role that materials play in our national defense, the area of solid-state devices should not be overlooked. An excellent example, the transistor, was a technological breakthrough which occurred shortly after the discovery of methods for producing super-pure materials in the form of highly perfect single crystals. These devices virtually revolutionized military electronics by setting the stage for miniaturization and increased reliability. The modern weapons now ensuring the security of our nation would probably have been impossible without the tremendous reduction in size and weight of their guidance, communication, and control systems. Close on the heels of these important military applications came widespread commercial ues in radio and television.

The potential of solid-state research has barely been scratched. Just recently, the maser, infrared detectors, and new magnetic materials have been developed as a direct result of such research. A major effort of the military-civilian scientific community is required to fully investigate in a timely, well coordinated manner the solid-state sciences. Methods of crystal preparation must be devised, and studies made of the properties of ultra-pure materials such as the rare earth elements, refractory metals, and intermetallic compounds. High-purity elements offer a means of building materials of desirable properties by introducing selected impurities or imperfections.

Microscopic crystals, termed "whiskers," have phenomenal mechanical properties compared to large, macroscopic crystals. Iron "whiskers," for example, have a strength on the order of 100 times that of bulk iron specimens. Concentrated study of these ultra-pure materials in fine filament, platelet, or thin-film form may unlock many secrets about creep and fatigue—problems which have long plagued aeronautical designers. Employment of these filaments could contribute significantly to microminiaturization and dramatic weight reductions of structural members. Research such as this in the solid-state sciences can ultimately result in many new materials for commercial use.

I became very keenly aware of the important role that materials play in our national defense efforts while directing the Air Force's ballistic missile development program. Many of our hardware problems had their roots in the basic materials of construction. Let me cite three examples connected with our work to solve reentry, propulsion, and guidance problems:

---

* Taken from an address presented at the President's Luncheon, Third Pacific Area National Meeting of ASTM, San Francisco, Calif., Oct. 14, 1959.

[1] Commander, Air Research and Development Command, Andrews AFB, Washington, D. C.

First, nose cones were required that could withstand the tremendous frictional heating and loading encountered upon reentering the earth's atmosphere. I consider the development of the nose cone which satisfied this requirement one of the outstanding scientific accomplishments of this century. The evaluation, testing, and selection of materials were of prime importance. You can readily understand that the urgency of the ballistic missile program would not permit a pure-research approach to the solution of this reentry problem. For example, we could not afford the time to start from scratch and come up with a test-tube material possessing all the characteristics required. We had to rely on materials that were already available in quantity and quality. Even so, it was necessary to devote valuable time collecting extreme-temperature property data on laboratory specimens and small models, and finally very expensive full-scale firings. Such an approach, although it yielded a successful solution for our first generation of missiles, was not without weight and performance penalties.

A second example I should like to cite concerns propulsion. The engines for the Atlas missile are a triumph of engineering. In this development, it was necessary to incorporate a regenerative cooling system since materials that could withstand the severe combustion temperatures were not, and still are not, available. Any cooling system adds weight and introduces engineering complications. This definitely extends our development cycle, increases costs, and degrades performance—all of which impedes our efforts to maintain a flow of superior weapons to our strategic and defensive air forces.

The third example I believe worthy of mention is the guidance system for the ballistic missile. It was quickly apparent that such a vehicle would need extremely accurate guidance if the warhead was to be delivered reliably to a military target thousands of miles from the point of launching. Such a guidance system must be producible in reasonable size, weight, and price for practical military application. The heart of this system, the steel gyro, required significant improvement. Development of a unique special metal gyro was a major contribution to the successful solution of this guidance problem.

As we advance from this first generation of Atlas and Thor missiles toward more sophisticated missile and space systems, demands placed on materials are even more severe. Extreme heat is the major problem. Aggravating this problem of heat will be a hostile environment consisting of high vacuum, cosmic radiations, dissociated and ionized gases. We are also concerned with dynamic conditions induced by high noise levels, accelerations, and decelerations.

From a materials point of view, these environmental trends boil down to two important facts: first, the search for new materials must be accelerated; and, second, such new materials must be made consistently available in quantity and quality upon which a designer can rely. In this regard, ASTM has one of the missions most responsible to our economic and military well being. The time-honored reputation of ASTM for unbiased research and evaluation of materials has helped assure the American public and governmental agencies that quality is built into the products they consume.

This quality requirement is vividly illustrated by the fact that many critical parts of rocket motors must be subjected to 100 per cent radiographic and ultrasonic inspection to ensure that no unsound welds or subsurface imperfections are present. ASTM standards help guide this inspection.

Historically, the evolution of a new material has been a lengthy process of development, testing, and production engineering. In our continuing job of strengthening the deterrent power of the United States, time is probably our most critical resource. We cannot afford the luxury of leisurely development. We must compress the usual consecutive phases into a program in which as many of these steps as possible are pursued concurrently. Let me illustrate with an example. Our search for rocket nozzle materials is being intensified. Concurrently with the development phase of materials is an integrated testing and evaluation program. First, potentially useful materials are fabricated into nozzles and fired in miniature rocket motors employing a variety of propellent combinations. The materials which show up best are then fabricated into full-scale nozzles and tested by a second contractor. The nozzles fired in both the miniature and full-scale facilities are examined metallurgically and evaluated by a third contractor. The results are quickly transmitted to all propellant and rocket engine developers.

Another management concept that has been introduced into our materials program is prototype evaluation. This approach is intended to fill the gap between laboratory results and construction of full-scale components. For example, in 1958 a large contractual effort was initiated to investigate the feasibility of utilizing available—and I want to emphasize this word available—heat-resistant materials for hypersonic leading edges. The boost-glide vehicle concept forms the basis for this study. Emphasis is being placed on reusable rather than expendable structures. Maximum temperature will range from 2500 to 3000 F. Ablation and cooling techniques are excluded. Four interrelated phases are being pursued; they involve design, materials evaluation, fabrication, and component testing. Design techniques for the employment of brittle heat-resistant materials are now in development. To date, many materials have been screened, eliminating all but a small, select list, such as silicon carbide, graphites, molybdenum alloys, and several heat-resistant coatings. These materials are now going through a rigorous laboratory testing program. Those that hold up the best will be fabricated into hypothetical leading edges and tested. Design criteria emerging from such a realistic program should greatly assist designers in the efficient employment of heat-resistant materials.

I do not want to give the impression that only prototype data are required. Equally serious is the lack of laboratory test methods and equipment that will reasonably simulate the complex stress fields and environmental conditions to which materials will be exposed. A good example of such a stress field is seen in the thin-wall motor case for solid-fuel rockets—essentially a pressure vessel. The builders of these cases must design them on the basis of laboratory data from materials samples that were uniaxially stressed. The cases are biaxially stressed. A large factor of safety must then be incorporated in the design, and many full-size cases pressure tested. If more sophisticated materials-testing procedures could be developed and standardized, time-consuming and expensive operations such as these with the rocket cases could be minimized.

We must be able to simulate the environment of space in our laboratories if the expense of full-scale firings into space to collect data is to be held to the absolute minimum. For just one launching of a research rocket into space—one that carries a reasonable payload—the cost can approach several millions of dollars. But since adequate laboratory simulation methods are lacking, this appears to be our most timely approach. I am thinking now of testing that involves more than one variable. For example, what are the combined effects of low vacuum, unattenuated ultraviolet radiation, temperature fluctuations, and high-speed particle erosion on a material under a fluctuating stress? Laboratory testing on each of these variables will give clues as to the individual effects. However, only by the development of combined environmental tests can the designer employ the results with a high degree of confidence. Effort by ASTM in developing and standardizing such testing procedures should contribute much toward this end.

A third principle we have introduced into the management of our materials

development program is one of calculated risk. Under such an approach, we are looking for technological breakthroughs that will give significant gains in materials capabilities. In other words, product improvement of well established commercial materials has been de-emphasized. Examples of materials on which work is now being stressed include beryllium and the refractory metals, graphite, inorganic rubbers, composite structures, fine filaments, and thermionic materials. New techniques, such as electron-beam melting, the use of extreme pressures and temperatures, and molecular engineering, are being exploited in our attempts to synthesize new classes of materials.

Much of this work must be considered in the calculated risk category because of the complexity of the technical problems to be solved. For example, there are severe brittleness problems associated with beryllium and the refractory metals. Graphite and the refractory metals oxidize rapidly at elevated temperatures. Considerable effort has been expended in the past few years to overcome these deficiencies, but progress has been slow. We are looking to the best in science and industry, which ASTM represents, to help us find satisfactory solutions to these problems.

The Soviets are also confronted with the high-temperature and spatial environments. We know they are concentrating on the development of materials to endure in these environments. They can use their dictatorial powers to channel practically unlimited funds and technical people into their military effort, and materials research and de-

Head table guests, President's Luncheon, San Francisco—caption on opposite page.

velopment is receiving a significant share of this attention. We cannot afford to be second best in this development race. The cooperation and participation of ASTM toward the rapid evolution of promising test-tube materials into reliable materials of construction will contribute immeasurably toward our success.

ASTM standards are an integral part of many military specifications, and many of our Air Force procurement contracts directly reference adherence to ASTM standards. Even wider use of ASTM documents can be expected. In fact, whenever possible we would like to use them without changing a single aspect, even the cover page. This will prevent needless duplication, waste of manpower, time, and money on our part to develop a comparable standard.

On the other hand, I ask ASTM to continue—even more so than in the past—its voluntary assistance in research and standardization of advanced materials. The help of ASTM is particularly invited for standards and environmental testing techniques for the newer materials such as beryllium, refractory metals, ceramics, and high-temperature coatings.

In summary, the military requirements for hypersonic and spatial flight coupled with high-speed reentry have introduced a new era in materials technology. Our actions must insure rapid development of improved materials whose quality and availability are guaranteed. Adherence to management principles designed to shorten the time span from test-tube to on-the-shelf materials capability will contribute significantly to the development of qualitatively superior air weapons.

I know that much of our military thinking and requirements are injected into the wide diversified efforts of ASTM because of our extensive membership and participation in the deliberations of its technical committees. I intend to continue my encouragement and support of this worth-while activity by my people in the Air Research and Development Command.

Head table guests, President's Luncheon, San Francisco—photos on opposite page.

Guests at the head table were: **C. W. Harris,** director, quality assurance and test services, Lockheed Aircraft Corp., Missile Systems Div. **W. M. Jaekle,** chief engineer, Southern Pacific Co., representing the American Railway Engineering Assn. **R. B. Jackman,** vice-chairman, Aerospace Research Testing Committee, Aerospace Industries Assn., Norair Div., Northrup Aircraft, Inc. **W. K. Woods,** manager, nuclear materials, General Electric Co., Vallecitos Atomic Laboratory. **Robert C. Miller,** director, California Academy of Sciences. **E. Finley Carter,** president, Stanford Research Institute. **L. A. O'Leary,** ASTM director and chairman, Finance Committee;* head, Chemical Engineering and Research Dept., W. P. Fuller & Co. **A. E. Raymond,** senior vice-president, engineering, Douglas Aircraft Co., Inc. **Rear Admiral L. V. Honsinger,** commander, Mare Island Naval Shipyard; past-president, American Society of Naval Engineers. **F. L. Crais,** manager, Products Engineering Dept., Standard Oil Company of Calif. **Louis G. Conlan,** president, City College of San Francisco. **John Fuller,** central region manager, W. P. Fuller & Co.

Miles N. Clair, ASTM vice-president; president, The Thompson & Lichtner Co. **Randolph Sevier,** president, Matson Navigation Co. **L. B. Worthington,** president, Columbia-Geneva Steel Div., U. S. Steel Corp. **R. A. Schatzel,** past-president, ASTM; vice-president and director of engineering, Rome Cable Corp. **Lt. General Bernard A. Schriever** (speaker) Commander, Air Research and Development Command, U. S. Air Force. **Paul V. Garin** (toastmaster), chairman, General Committee on Arrangements;* former ASTM director; manager, research and development, Southern Pacific Co. The Honorable **George Christopher,** Mayor of San Francisco. **Frank L. LaQue,** ASTM president; vice-president and manager, Development and Research Div., The International Nickel Co., Inc. **Dan A. Kimball,** president, Aerojet-General Corp. **Richard T. Kropf,** past-president, ASTM; vice-president and director of research, Belding Heminway Co.

J. M. Hait, executive vice-president, Food Machinery and Chemical Corp. **K. B. Woods,** ASTM past-president; head, School of Civil Engineering, and director, Joint Highway Research Project, Purdue University. **Lt. General Robert M. Cannon,** Commanding General, Sixth U. S. Army. **A. Allen Bates,** senior vice-president, ASTM; vice-president of research and development, Portland Cement Assn. **S. L. Sibley,** vice-president and general manager, Pacific Gas and Electric Co. **C. W. Turner,** president, American Bitumuls and Asphalt Co. **Major General Stuart D. Menist,** chairman, Armed Forces Section, San Francisco Chamber of Commerce. **Theo. P. Dresser, Jr.,** honorary chairman, General Committee on Arrangements;* former ASTM director, past-chairman, Northern Calif. District Council; chief engineer, Abbot A. Hanks, Inc. **W. T. Lewis,** vice-president, Pacific Metals Co., Ltd. **Paul E. McCoy,** vice-chairman, General Committee on Arrangements;* past-chairman, Northern Calif. District Council; assistant to vice-president, American Bitumuls and Asphalt Co. **Glenn Koger,** vice-president and general manager, west coast operations, Rome Cable Corp. **L. A. Elsener,** vice-president, ASCE; Chicago Bridge and Iron Co. **R. E. Hess,** ASTM associate executive secretary.

H. de Bussieres, vice-chairman, Social Committee;* vice-president and manager, Curtis & Tompkins, Ltd. **W. L. Fink,** ASTM director; scientific coordinator, Aluminum Company of America Research Laboratories. **Byron P. Weintz,** chairman, ASTM Southern Calif. District council; chief engineer, Consolidated Rock Products Co. **H. Dana Moran,** secretary, technical service, Aerospace Industries Association of America, Inc. **William M. Barr,** ASTM past-president and honorary member; research consultant. **R. N. Connor,** vice-chairman, promotion and publicity;* manager, Baldwin-Lima-Hamilton Corp. **F. W. Twining,** vice-chairman, promotion and publicity;* managing director, The Twining Laboratories. **H. C. Miller,** ASTM director; laboratory engineer, Testing Laboratory, Public Service Electric & Gas Co. **E. W. Gardiner,** vice-chairman, Finance Committee;* research coordinator, California Research Corp.

L. J. Markwardt, ASTM past-president; assistant director (retired), U. S. Forest Products Laboratory. **T. K. Cleveland,** chairman, promotion and publicity;* chief chemist, Philadelphia Quartz Co. of California. **H. M. Hancock,** ASTM director; manager, Product Control Dept., The Atlantic Refining Co. **Jonmore Dickason,** vice-chairman, Finance Committee;* general manager, Metal Control Laboratories, Inc. **R. C. Vollmar,** vice-chairman, Technical Program Committee;* secretary, ASTM Northern Calif. District Council; refinery chief chemist, Standard Oil Company of California. **A. E. Juve,** ASTM director; director, technical service research, The B. F. Goodrich Research Center. **Roy Henning,** chairman, industry luncheons;* Eitel-McCullough, Inc. **R. W. Harrington,** chairman, Social Committee;* chairman, ASTM Northern Calif. District Council; manager, Clay Brick & Tile Assn., Region 16A, Structural Clay Products Inst.

G. J. Grieve, chairman, Technical Program Committee;* vice-chairman, ASTM Northern Calif. District Council; manager, transportation sales, Pacific Paint & Varnish Co. **C. M. Wakeman,** honorary vice-chairman, General Committee on Arrangements;* testing engineer, Los Angeles Harbor Dept. **Raymond E. Davis,** honorary vice-chairman, General Committee on Arrangements;* director emeritus, Engineering Materials Laboratory, University of California, Berkeley. **W. C. Hanna,** honorary member of ASTM and honorary vice-chairman, General Committee on Arrangements;* vice-president in charge of technical developments, California Portland Cement Co. **R. D. Thompson,** ASTM director; chief development engineer, Taylor Instrument Companies. **Don Bowers,** vice-chairman, industry luncheons;* secretary, Southern Calif. District Council; General Petroleum Corp. **John H. Koenig,** ASTM director; director, School of Ceramics, Rutgers University. **R. W. Seniff,** ASTM director; manager of research, The Baltimore & Ohio Railroad Co. **C. L. Clark,** ASTM director; metallurgical engineer, Special Steel Developments, The Timken Roller Bearing Co., Steel and Tube Div.

C. F. Fitzwilson, chairman, Information Committee;* chief metallurgical engineer, Columbia-Geneva Steel Div., U. S. Steel Corp. **R. E. Peterson,** ASTM director; manager, Mechanics Dept., Westinghouse Electric Corp., Research Laboratories. **Ernst Maag,** vice-chairman, Technical Program Committee;* principal structural engineer, California State Dept. of Public Works, Div. of Architecture. **A. B. Cornthwaite,** ASTM director; engineer of materials and tests, Dept. of Highways, Commonwealth of Virginia. **C. F. Lapier,** chairman, Transportation Committee;* general purchasing agent, Matson Navigation Co. **H. D. Wilde,** ASTM director; research coordinator, Humble Oil and Refining Co. **Frank H. Jackson,** honorary member, ASTM; consulting engineer, Chevy Chase, Md. (retired principal engineer of tests, U. S. Bureau of Public Roads). **M. C. Poulsen,** vice-chairman, Plant Visits Committee;* secretary and engineer, Port Costa Brick Works. **P. A. Archibald,** ASTM director; chief metallurgist, Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. **G. F. Scherer,** vice-chairman, Information Committee;* vice-president and director of research, Nordstrom Valve Div., Rockwell Mfg. Co. (*Not in photograph*)—**John E. Rinne,** national director, ASCE; Standard Oil Company of California. **E. V. Noe,** chairman, Plant Visits Committee;* chief, Bureau of Specifications and Estimates, Dept. of Engineering, Pacific Gas & Electric Co.

* Third Pacific Area National Meeting.

ASTM, Materials, and Progress*

By F. L. LAQUE[1]

THE WORDS ASTM, Materials, and Progress, can be arranged in six ways. The sequence used in the above title is the one that first came to mind. After examining all the other possibilities, it still seemed to be the best. The order represents a series in which each following word suggests a contribution from the preceding one so as to form a natural progression. On such a basis it would be possible to defend other arrangements. For example, one could assert that advances in materials depend on progress as much as progress depends on advances in materials. But the latter relationship is the one that I wish to emphasize.

Similarly, one could claim that the growth of the ASTM in size and importance must be influenced by progress in general and that it benefits from increases in the importance of materials. But since I wish to deal with the contributions of the ASTM to both materials and progress, it is in order that the ASTM should be given first billing.

First, let us review some of the ways in which the ASTM takes part in improvements in materials.

This begins with the Society's research activities under the over-all guidance and stimulation of its Administrative Committee on Research and through the activities of its several working committees. The results of this research are aimed more or less directly at some new or improved standard, test procedure, or recommended practice, which are the final products of the principal ASTM activities. In many cases, research described in papers presented before the Society and printed in its publications is not identified immediately with any particular standard, procedure, or practice, but in practically every case the results sooner or later extend or improve these ASTM end products.

There is little need to emphasize the contributions to progress that are made by ASTM Standards. In a very practical way, they enable users of materials to describe what they want. They enable producers to place realistic boundaries on the compositions and properties of what they are able to furnish commercially in response to their customers' demands and needs. Since these standards are dynamic and subject to continual revision as improved compositions and properties become commercially feasible, they are not only responsive to such advanced needs, but serve very well to reflect the progress to which the work of the ASTM has contributed.

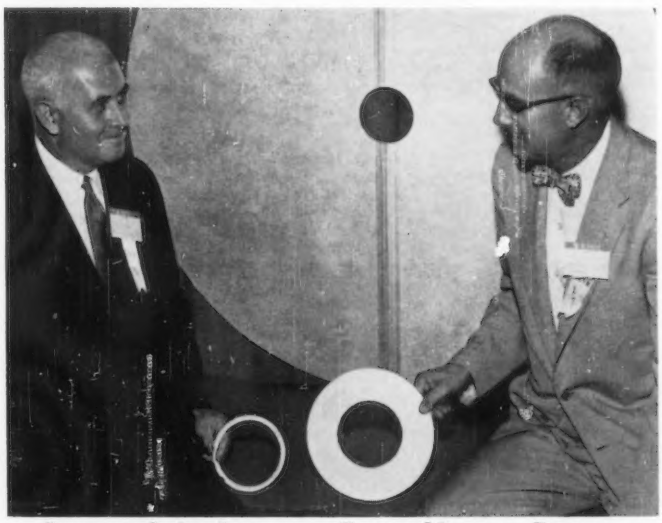
By defining realistically the levels of properties that can be depended upon, the ASTM Standards enable engineers to design with lower factors of safety—sometimes called factors of ignorance. This, in turn, permits savings in cost and weight, which make advanced designs of structures and machines economically feasible. It also serves to conserve our resources by avoiding the wasteful use of the excess material that would be required if materials could not be used with the precision that the ASTM Standards permit.

The Society's publication of technical papers in its annual *Proceedings*, its special technical publications, and the ASTM BULLETIN augments an ever-growing reservoir of sound knowledge of the properties of materials and how best to evaluate them. There is no need to elaborate on this contribution to progress. By way of example, one need refer only to the program of this present meeting, which is the largest ever held by the Society in terms of the number of technical sessions and of papers to be presented. A mere glance at the titles of the some 230 papers in fifty technical sessions is a convincing demonstration of the contribution that the Society is making to our knowledge of materials and their useful properties.

The importance of materials to progress in general hardly needs to be emphasized. One can instantly bring to mind some scientific or engineering development that has been, or still is, dependent on improvements in materials. However, a few examples will be mentioned as reminders.

Further advances in the economical generation of power from nuclear sources will depend more on improvements in materials and the way they are used than on solutions of problems in the realm of atomic physics.

The extent to which man will be able to journey into outer space and especially to return safely, and the time that must elapse before such activities become practical will be controlled principally by the solution of materials problems. This is illustrated by the importance of the choice of material for nose cones of space vehicles so that



PRESIDENT LAQUE ILLUSTRATES TALK ON MATERIALS PROGRESS

ASTM President Frank L. LaQue (*left*), holds cross-section of low-alloy steel pipe used with steam at 2000 psi pressure and 800 F. In the back—the cross-section of pipe that would be needed if same steel were to be used at 5000 psi and 1200 F. At the right, Fred F. Van Atta, assistant secretary, ASTM, holds cross-section of nickel stainless steel pipe being used with steam at 5000 psi pressure and 1200 F.

* Taken from an address presented at the President's Luncheon, Third Pacific Area National Meeting of ASTM, San Francisco, Calif., Oct. 14, 1959.

[1] President, ASTM, and vice-president and manager, Development and Research Div., The International Nickel Co., Inc., New York, N. Y.

they can survive the heating effects encountered when reentering the earth's atmosphere.

The more economical generation of steam power using coal, oil, or gas as fuel is dependent on operating at as high a temperature and pressure as possible in the boilers, steam lines, and turbines. Since 1905, the operating pressures and temperatures in steam power plants have risen from 200 psi at 500 F to 5000 psi at 1200 F.

The economic advantages that have paralleled this trend are illustrated by the fact that in 1905 it took 6 pounds of coal to produce 1 kilowatt-hour of power; today, the rate is 1 pound per kilowatt-hour. The demands for better materials that accompany these advances are illustrated by noting that if the same steel had to be used for piping for the 1200-F, 5000-psi plant as was adequate for a once-common 800-F, 2000-psi plant, the wall thickness of a 5-in. steam line would have to be increased from about $\frac{3}{8}$ in. to about 25 in. As it is, the alloy steel being used for a 5-in. pipe in a 1200-F plant has to be $2\frac{3}{8}$ in. thick. Alloys now in an advanced stage of development will probably reduce this thickness to about $\frac{1}{2}$ in.

Similar trends toward greater efficiency through operation at higher temperatures are evident in the jet engines used to power our military and civilian aircraft. The alloy that was developed for the blades in Whittle's first jet engine, and which actually made this engine practical, was good enough to operate at 1200 F. The latest development in the same series of alloys is stronger at 1500 F than the original alloy was at 1200 F. In the Whittle engine design, quite high blade stresses were inherently involved. With current engine design practice, the newer alloy is capable of operating at blade temperatures of 1700 F and, in some instances, 1800 F. As stronger alloys capable of operating at even higher temperatures become economically available, the designers of jet engines are already able to make effective use of them. Here again is a striking example of the controlling effect of material improvements on the rate of engineering progress.

While we are speaking of progress in materials, it is most appropriate to recall the contributions that have been made by the research organizations of the Air Force. In its own laboratories and through the research it has sponsored and stimulated elsewhere, the Air Force has had a tremendous influence in improving the quality and properties of all kinds of materials and in bringing about the commercial development of new ones.

Many are inclined to characterize war and the steps taken to avoid war by becoming so strong as to make war unattractive to our enemies as being unduly wasteful of our resources and energies. Such an attitude fails to take into account the benefits outside the fields of war and defense that are derived from the efforts for these purposes. Results of these efforts are frequently put to more extensive and more persistent use in what we can call civilian applications.

An old example is the armor-plate steel developed by Krupp prior to World War I. This steel has been used ever since for heavy-duty gears and bearings and probably has served mankind more effectively and to a greater extent for these purposes than it ever did for the warlike purpose that stimulated its development.

Consider another turbine blade. The alloy from which it was made was developed for use in a jet engine to power a military airplane. But this blade is to be used in a steam turbine for a commercial power plant to operate under the 1200 F and 5000 psi conditions mentioned before. One wonders whether this alloy would have been available for this use when it was required if the needs of defense had not made possible an alloy development effort that no speculative civilian application could stimulate or support.

So, let us not forget the benefits that peaceful uses derive from the acceleration of materials development programs that our defense needs bring about. And let us be thankful that the national importance of these defense needs and the challenge they present are sufficient to attract to the defense effort people of the calibre of today's guest speaker, General Schriever, and the thousands of his associates whom he represents on this occasion.

In conclusion, I should like to remind you of the motto of the air force of my homeland, Canada. It reads, *Per Ardua ad Astra.* With some freedom in translation, this says that if we work hard enough to overcome our adversities we can reach the stars. I am confident that the ASTM will carry its part of the load in overcoming the difficulties that arise in the field of materials. I am equally confident that General Schriever and those working under his direction will take care of their many problems so that before long we shall overcome all our adversities, conquer outer space and, ultimately, reach the stars.

Credit for a Successful West Coast Meeting

A large share of the credit for the success of the Third Pacific Area National Meeting must go to the able and hard-working men of the General Committee on Arrangements. Officers of the committee were:

P. V. Garin, chairman, Southern Pacific Co., San Francisco.
P. E. McCoy, vice-chairman, American Bitumuls and Asphalt Co., San Francisco.
M. B. Niesley, vice-chairman, California Testing Laboratories, Inc., Los Angeles.
H. P. Hoopes, secretary, Fibreboard Paper Products Co., San Francisco.
L. A. O'Leary, treasurer, W. P. Fuller and Co., South San Francisco.

Fracture Tests for High-Strength Sheet Materials

In January, 1959, as the result of a suggestion from the Department of Defense, a group of experts was appointed as a Special ASTM Committee on Fracture Testing of High-Strength Sheet Materials. After five meetings during the year, every one of which consisted of at least one full day of intensive discussion, the group is planning to publish a report in the January and February issues of the ASTM BULLETIN. Most of the members of the committee will be responsible for various sections of the report. Present plans call for the report to consist of four parts as follows:

Introduction.—Origin and scope of the committee. A description of the problem, encompassing a design test for fracture stress analysis as applied to sheet, and a screening test.

Design Test.—Definitions, theoretical background, graphic solutions, and design of test specimens for the determination of fracture toughness parameters.

Screening Tests.—The edge-notched specimen, center-notched specimen, unnotched bend specimen, and dynamic notch test, including a description of the test, measurements made, and quantities derived; also a justification of the tests on the basis of requirements for the screening test and a correlation with service behavior or with fracture mechanics.

Concluding Statement.—A summary of the report and any conclusions reached.

With this report the committee expects to solicit comments of industry in general. These comments will then be used with the information already available to the committee for the development of one or more ASTM test methods.

These West Coast Papers Are Still Available

A LIMITED number of the following papers are available from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at a charge of 50 cents each. Please include the paper number (shown in parentheses) with your order.

Discussion of any of these papers must be submitted by **January 15, 1960**, for consideration for publication with the paper.

Symposium on Bituminous Waterproofing and Roofing Materials

This is Your Roofing Asphalt—Its Composition and Rheology—A. B. Brown and S. W. Sparks (1).

Some Qualitative Effects of Composition and Processing on the Weatherability of Coating Grade Asphalts—E. W. Mertens and S. H. Greenfeld (2).

Manufacture and Application of Asphalt Roofing—L. C. Haack (3).

Industrial Pitches—C. U. Pittman and J. W. Donegan (5).

Asphaltic Grouts, Mastics, and Cold-Applied Cements—W. L. Butterfield and F. H. Haney (6).

Symposium on Road and Paving Materials

Progress Report on the Zaca-Wigmore Experimental Asphalt Test Project—F. N. Hveem, E. Zube, and J. Skog (8).

Effect of Temperature on the Flexibility Characteristics of Asphaltic Paving Mixtures—C. L. Monismith (11).

Symposium on Soils for Engineering Purposes

Measurement of Excess Hydrostatic Pressures in Soils—W. G. Weber, Jr. (15).

Moisture and Strength Variation in a Thick, Uniform Clay Layer—W. G. Weber, Jr., and W. F. Kleiman (16).

Extended Repetitive Plate Load Tests for the Evaluation and Design of Concrete Pavements—B. B. Gordon (17).

Some Laboratory Studies of the Moisture-Density Relations of Soils—R. F. Dawson (18).

Symposium on Effect of Water-Reducing and Set-Retarding Admixtures on Properties of Concrete

Actions of Calcium Sulfate and Admixtures in Portland Cement Pastes—W. C. Hansen (25).

Discussion of W. C. Hansen's paper—H. H. Steinour (25A).

Detection of Lignosulfonate Retarder in Cement Suspensions and Pastes—E. G. Swenson and T. Thorvaldson (29).

Field Experience Using Water-Reducers in Ready-Mixed Concrete—E. L. Howard, K. K. Griffiths, and W. E. Moulton (30).

Introduction to Producers' Papers on Water-Reducing Admixtures and Set-Retarding Admixtures for Concrete—M. E. Prior and A. B. Adams (31).

Effect of Water-Reducing Admixtures and Set-Retarding Admixtures on the Properties of Plastic Concrete—C. A. Vollick (32).

Summary of Effect of Water-Reducing and Set-Retarding Admixtures on Properties of Concrete—B. Foster (35).

Symposium on Methods for Testing Building Constructions

The Testing of Diaphragms to Determine Adequacy in Resisting Horizontal Forces—S. B. Barnes (43).

Testing of Large Diaphragms—R. D. Cousineau (44).

Lateral Shear Tests of a Light-Gage Steel Building—J. J. Holstein (45).

Determining the Useful Strength of Yard Lumber of the Common Grades—T. K. May (46).

Symposium on Wood in Building Construction

Need for Special Engineering Education in the Field of Structural Timber Design—R. A. Glaze (48).

Quality Control and Inspection—F. J. Hanrahan (49).

Deflection Limitations in Structural Timber Design—R. E. Eby (50).

Strength Studies of Scarf Joints in Laminated Wood Beams—J. Longworth and K. A. Stieda (51).

Screw-Holding Ability of Western Woods: Effects of Test Variables—J. W. Johnson (52).

Termite Control in California Residential Construction—W. Ebeling (54).

Wood-Pole-Type Buildings—W. D. Keeney (55).

Strength and Related Properties of Wood Poles—E. C. O. Erickson and L. W. Wood (56).

Symposium on Paint

Use of the Stormer Viscometer for Testing Rotogravure and Flexographic Inks—R. Cummings (64).

Use of a Modified McMichael Viscometer for Consistency of Printing Inks and Ink Vehicles—R. Cummings (65).

Water Permeability Studies on Latex and Latex Paint Films—R. C. Simon (66).

Symposium on Fatigue of Aircraft Structures

Quantitative and Systematic Attack on Fatigue—E. T. Haire (70).

Development of Loading Spectra for Testing Aircraft Components and Structures—A. J. McCulloch (71).

A Test Method for Sonic Fatigue—R. H. Vreeland (72).

Low-Cycle Fatigue Strength of Pressurized Components—J. Padlog (73).

Development Fatigue Testing of a Large Helicopter Rotor Blade—A. A. Lischer (74).

Production Methods of Cold Working Joints Subjected to Fretting for Improvement of Fatigue Strength—K. T. Waters (75).

Designing Fatigue Resistant Structures—C. R. Smith (76).

A Method for Predicting the Rate of Fatigue Crack Propagation—A. J. McEvily, Jr. and W. Illg (77).

Variable-Amplitude Fatigue Tests of Aluminum Alloy Specimens—H. F. Hardrath and E. C. Naumann (79).

Fatigue-Strength Comparisons of Forged Magnesium Alloys—E. H. Schuette (80).

Symposium on Durability and Weathering of Structural Sandwich Constructions

Effect of Aging Under Normal Service Conditions on Physical Properties of Glass Fabric-Plastic Honeycomb Core—A. C. Marshall (82).

Effect of Natural Environment on Sandwich Structure Fabricated Using AMS 3722 Paper Honeycomb Core—R. F. Zemer (83).

Effect of Environmental Exposure on Adhesive Bonded Structures—A. J. Tuckerman (84).

Service Experience of Sandwich Construction—Some Approaches to Problems in Aircraft Applications—J. P. Reese (85).

Temperature Rise in Structures Due to Solar Heating—D. K. Rider (86).

Effect of Climatic Variations on the Performance of Polystyrene Foam Core Sandwich Panels in Roofs and Walls—E. A. Edberg (87).

Symposium on Technical Development in the Handling and Utilization of Water and Industrial Waste Water

Disposal of Industrial Radioactive Waste Waters at Hanford—L. C. Schwendiman, R. E. Brown, J. F. Honstead, C. E. Linderoth, and D. W. Pearce (91).

Determination of Radioactive Materials in Water—F. B. Barker (92).

Utilization of Cooling Towers in Conservation and Pollution Control Programs—J. J. Finnerty (93).

Improvements in Water Treatment for Once-Through Reactor Cooling—R. B. Richman (94).

Disposal of Oil Field Brines in the Central Valley of California—J. M. Morris, Jr. (95).

Cities Can and Must Provide Municipal Waste Treatment, Not Sewage Treatment—J. E. Kinney (96).

Field Testing of Corrosion Inhibitors in Sea Water—C. C. Wright (97).

Effect of Industrial Wastes on Water for Irrigation Use—L. V. Wilcox (98).

Operation of Batch-Type and Continuous Electric Membrane Demineralizers on the Municipal Water Supply at Coalinga, California—W. E. Katz (99).

Present Status of Solar Distillation of Saline Water With Particular

Regard to Materials Problems—R. P. Lappala, L. L. Yaeger, and J. A. Bjorksten (100).

Symposium on Air Pollution Control

Wind and Weather Summaries for Chemical Plant Design and Air Pollution Control—R. J. Moore, T. D. Boscia, and R. W. Lundeen (102).

Determination of Gaseous and Particulate Inorganic Fluorides in the Atmosphere—M. R. Pack, A. C. Hill, M. D. Thomas, and L. G. Transtrum (106).

Symposium on Newer Metals

Test Methods Used for Zirconium and Zirconium Alloy in the Naval Reactor Program—H. L. Kall (114).

Survey of the Mechanical Properties of Yttrium and Yttrium Alloys—O. N. Carlson, D. W. Bare, E. D. Gibson, and F. A. Schmidt (116).

Columbium and Tantalum Fabrication—H. M. McCullough (117).

The Solubility of Nitrogen and Oxygen in Lithium and Methods of Lithium Purification—E. E. Hoffman (121).

Coulometric Determination of Tin with Electrolytically Generated Iodine: Application to Analysis of Zircaloy—R. D. Caton, Jr., and H. Freund (122).

Symposium on Standards–Are Changes in Order?

Sound Standards Stimulate Manufacturing—P. McCoy (123).

Comments on ASTM Standards for Highway Materials—F. N. Hveem (125).

Symposium on Hydraulic Fluids

Industrial: Are Hydraulics Holding Their Own?—R. Q. Sharpe and K. G. Henrikson (128).

Automotive Central Hydraulic Systems and Their Fluid Requirements—T. H. Risk (129).

Is Hydraulics Out of this World?—G. R. Keller (130).

Spray Flammability Test for Hydraulic Fluids—H. H. Rowand (131).

New Developments in High Performance Fluids for Military Aircraft and Commercial Industrial Applications—T. G. Smith (133).

Emulsion-Type Fire-Resistant Industrial Hydraulic Fluids—C. E. Francis and H. E. Sipple (134).

Development and Testing of Aircraft Hydraulic Fluids—R. L. Peeler and S. A. Kovacich (135).

Symposium on Electrical Insulating Materials

Development of Improved Insulating Oils—N. W. Furby and F. J. Hanly (136).

Activities of the International Electrotechnical Commission Dealing with Electrical Insulating Materials—A. H. Scott (140).

Symposium on Adhesion and Adhesives

Lap Shear and Creep Testing of Metal-Adhesive Bonds in Germany—K. F. Hahn (142).

Symposium on Reinforced Plastics

Test Procedure for Obtaining Mechanical Properties of Filament Wound Materials—W. R. McCarthy (146).

Permeability of Materials Under High Pressures and at Various Temperatures—G. Epstein and W. W. Gary, Jr. (149).

Symposium on Thermal Ablation

Photographic Technique of Surface Temperature Measurement—J. H. Siviter, Jr. (156).

Ablation and Erosion in the Rocket Environment—S. H. Herzog and W. E. Donaldson (159).

Symposium on Post-Irradiation Effects in Polymers

The Significance to ASTM of Post-Irradiation Effects in Irradiated Materials—D. S. Ballantine (163).

Electron Spin Resonance Studies of Free Radicals in Irradiated Materials—L. A. Wall (164).

Post-Irradiation Oxidation and Molecular Weight Changes in Polystyrene and Polymethyl Methacrylate—W. W. Parkinson and D. Binder (165).

Post-Irradiation Dielectric Properties of Silicones—C. G. Currin (166).

Post-Irradiation Effects: Monomers and Polymers—E. F. Degering, G. J. Caldarella, and M. Mancini (167).

Symposium on Applied Radiation and Radioisotope Test Methods

Radioactive Ring Wear Testing in Railroad Diesel Locomotive Engine—C. F. Jursch, P. L. Pinotti, and D. R. Jones (170).

Grain Boundary Segregation Studies by Activation—W. W. Schultz (171).

Removal of Radiotagged Fatty Soil From a Glass Surface—J. C. Harris and R. M. Anderson (172).

Calcium-45-Tagged Clay as a Detergency Test Soil—J. W. Hensley (173).

Measurement of Moisture and Density in Soils by the Nuclear Method—J. Kuranz (174).

A Radiometric Method for the Determination of Magnesium Oxide in Portland Cement—J. E. Howes, Jr., C. T. Brown, D. N. Sunderman, M. Pobereskin, and P. Schall (176).

Permeability Tests for Organic Sheet Materials—M. Pobereskin (179).

Uniformity Tests for Coated Fabrics—G. B. Foster (180).

Transcript of First ASTM Forum on Nuclear Problems (183).

Symposium on Radiation Effects and Dosimetry

The Radiochemical Determination of Uranium Burnup—D. N. Sunderman (184).

Recent Developments in Gamma Dosimetry—S. I. Taimuty (185).

Techniques for Measuring Reactor Neutron Spectra—J. B. Trice (186).

Reactor Monitoring by Calorimetry—K. L. Hall, R. F. Klaver, J. G. Carroll, and R. O. Bolt (187).

Removal Dose as an Environmental Measurement of X-Rays and Gamma Rays—R. L. Hickmott (188).

Dosimetry in Europe and the USSR—J. H. Guill and J. Moteff (190).

The Effects of Gamma Radiation on Some Electrical Properties of Teflon—W. E. Loy, Jr. (193).

Atomistic Interpretation of Radiation Effects in Metals—A. Sosin (195).

Irradiation of Some Pressure Vessel Steels—L. P. Trudeau (196).

Neutron Radiation Embrittlement at 500 F and 650 F of Reactor Pressure Vessel Steels—J. V. Alger and L. M. Skupien (197).

Symposium on Ceramics in Nuclear Energy

Dry Pressing Ceramic Fuel Elements to Close Tolerances—F. J. Hartwig (202).

Fabrication and Evaluation of Urania-Alumina Fuel Elements and Boron Carbide Burnable Poisons—L. Wisnyi and K. Taylor (204).

Graphite as a Fuel Matrix—W. C. Riley (206).

Symposium on Nondestructive Testing in the Missile Industry

Radiography of Large Solid-Propellant Rocket Motors—E. L. Criscuolo, J. A. Holloway, D. Polansky, and C. H. Dyer (208).

Mobile Field Testing of Missiles and Aircraft—A. Barath and D. J. Hagemaier (209).

Radiography of Weldments In-Motion—W. C. Hitt and D. J. Hagemaier (211).

Symposium on Spectroscopy

Spectroscopy of Radioactive Materials—J. G. Conway (218).

Communications in Spectrochemical Analysis—D. L. Fry (219).

The Future of X-Ray Fluorescence Instrumentation—J. W. Kemp (220).

Application of X-Ray Spectroscopy to Unsolved Problems in Geochemistry—I. Adler (221).

Quantitative Light Element Analysis, Fe to Mg, for Portland Cement by X-Ray Spectrography—E. A. Curley (223).

Spectroscopy in the Region 175 to 200 mμ—W. Kaye (225).

Special Problems in the Determination of Tetraethyllead in Gasoline by Flame Photometry—B. E. Buell (228).

The Unpaired Electron via EPR—R. H. Sands (230).

Maser Applications and Traveling-Wave Techniques for Magnetic Resonance Spectroscopy—A. E. Siegman (232).

Some Comments Concerning Quantitative Infrared Spectroscopy—W. C. Steele and M. K. Wilson (234).

Ten Years of Aid to Applied Absorption Spectroscopy by Committee E-13—R. F. Robey (237).

The Combination of Methods in the Analysis of Complex Hydrocarbon Systems—N. D. Coggeshall and W. Hubis (238).

Molecular Spectroscopy in the USSR—D. G. Rea (240).

ASTM Bulletin

No. 242 December 1959

Nineteen-Sixteen
Race Street
Philadelphia 3, Pa.

More on Education in Materials

The ASTM-ASEE Symposium on Education in Materials, held at the 62nd ASTM Annual Meeting last June, has been the subject of a number of comments in the technical press. This is, we believe, symptomatic of the growing realization that materials problems occupy a central position in today's technology. We were particularly interested in the editorial, "The Materials Side," in the September issue of *Industrial and Engineering Chemistry*. It said, in part:

More education must be done to give the engineer at least the basics in materials choices. Dr. Warren [Glenn B. Warren, vice-president, Turbine Division, General Electric Co., and president of ASME, who helped to present industry's viewpoint at the symposium] thinks that fundamentals of mechanics and materials, physical properties under all kinds of conditions, applications, and production of materials are the most important factors. To achieve this there must be a redesigning of some of our engineering curricula. The ASTM, of course, is particularly interested in graduate courses in materials engineering. But materials education must penetrate all the engineering courses, and at all levels.

We were interested in a remark by Penn State's president Eric Walker: "Most of our troubles with engineering stem, it sometimes seems to me, from the fact that our programs have never really been *designed* . . . We have failed to apply the same sort of scientific approach in devising our educational programs that we expect engineers to use in solving their problems." The British Institution of Chemical Engineers has just this year issued a new brochure titled "Scheme for a Full-Time Course in Chemical Engineering," revising some of the thinking of 14 years ago when attention was directed to designing chemical engineering curricula in British schools of higher learning. We think one of the outstanding statements in this brochure is: "The student must be taught from the beginning that money and economics as well as scientific principles are a part of plant design." Certainly proper choice of materials plays a heavy role in plant design economics.

And, we hasten to add, in every other kind of design economics.

OFFERS OF PAPERS FOR 1960

THE Administrative Committee on Papers and Publications will meet in early February to consider the papers to be published by the Society in 1960 and to develop the program for the Annual Meeting to be held in Atlantic City June 26–July 1.

All those who wish to offer papers for presentation at the meeting and publication by the Society should send these offers to Headquarters *not later than January 10, 1960.*

All offers should be accompanied by a summary that makes clear the intended scope of the paper and indicates features of the work that will, in the author's opinion, justify its publication and inclusion in the Annual Meeting program.

Suitable blanks for use in transmitting this information will be sent promptly upon request to Headquarters.

H. C. Miller Represents ASTM At Cooper Union Centennial

H. C. MILLER, a National Director of ASTM, represented the Society at a convocation on Nov. 2, held to mark the 100th anniversary of the opening of The Cooper Union for the Advancement of Science and Art, in New York City.

The centennial celebration, which opened on Sept. 17 with a cornerstone laying for the new engineering building, will continue through the academic year. A number of special lectures, exhibits, and other gatherings are scheduled.

The doors of the Cooper Union were formally opened on Nov. 2, 1859. The day-long convocation on Nov. 2, 1959 was addressed by distinguished speakers from the fields of science, art, and government. Following a dinner at the Waldorf-Astoria, Lester B. Pearson, former president of the General Assembly of the United Nations and a winner of the Nobel Peace Prize, spoke on "Government and Society."

MATERIAL QUESTIONS

Nuts and Washers for High-Tensile-Strength Structural Bolts

In reading the May issue of the ASTM BULLETIN, I was surprised by an instance of a misquotation of a Society standard. The specific item that I noted is a question-and-answer concerning the A 325 specification for bolts and nuts in the "Material Questions" column on p. 13.

The question about bolts and nuts is answered on the basis of the 1955 edition of specification A 325, even though this has been superseded for nearly a year by the 1958 edition of the specification. Additionally, the answers given are not correct even for the older edition of the specification. The selection of 1½-in. diameter as the limit for mandatory full-size testing was based on use and not on testing machine limitations. Further, this size of nut required a proof load of 80,100 lb in the 1955 specification and could never have been tested on a 60,000-lb testing machine. The answer also implies that tempering is necessary to attain high hardness, yet for the steels involved, tempering is a softening process.

● The question and answer on Specification A 325 had been held for about three years until decision was reached to publish such a question and answer column in our BULLETIN. As you noted, some of the statements are out of date in view of the publication of A 325-58 T.

In regard to the statement on tempering for arriving at final hardness, this was intended to point out that the high level of hardness to which the inquirer was objecting was actually a tempered hardness to eliminate any brittle condition. It was never intended to imply that tempering produced a higher hardness.

Effects of Ultraviolet Exposure on Plastics

Will you please advise us which is the best method for testing white, translucent, rigid vinyl plastic sheet for the effects of ultraviolet energy in the wavelengths between 2800 and 4000Å?

We are working with an architect who is requesting a test for comparing various types of rigid vinyl plastic sheets 0.015 in. thick. We are concerned primarily with ultraviolet energy and we are interested in a test which would take the least time, yet show a fair comparative result.

We would appreciate your comments on the merits of a carbon-arc test, a sunlamp test, or some other method for best indicating the effects of ultraviolet exposure on plastics.

● We know of no studies made on plastics in which the effects of particular wavelengths of ultraviolet light were considered. The colorfastness tests used cover a wide range of wavelengths, generally from 2800 to 6000Å. Although carbon-arc machines may give shorter wavelengths, filters are used to cut off the short wavelengths.

The effectiveness of a test method for fading or weathering must be judged from an estimate of the service conditions, because there are no standards for judging

such test methods. There is no reliable method for translating accelerated test results into service life. This problem has been studied by many laboratories in the plastics industry, but the results to date are negative.

The procedure that we would recommend for evaluating the vinyl chloride plastic sheet that you describe is as follows: We would measure the color, reflectance, light transmission, and haze of specimens and then divide them into five groups. One group would be held as a control, the second would be exposed to radiation from an S-1 bulb, the third to radiation from a fluorescent sunlamp bulb, the fourth to a carbon-arc machine (Fade-ometer), and the fifth outdoors facing south under glass. The specimens would be removed at intervals for testing and then replaced. The intervals would be set by changes in appearance. After significant changes in properties were obtained, the type and character of the changes would be judged against the type and character of the changes expected for this particular plastic on the basis of experience. Then on the basis of previous experience with these test methods, a very rough estimate of the service life might be made. The comparison of different products with one another is more readily made.

Any single fading test method can be used to compare materials. This will tell you which materials are better than others in that test method. To translate these results into service life and behavior requires experience and further study.

We can make no recommendations on the relative merits of sources of ultraviolet radiant energy for your purpose. Presumably, any source would be suitable provided filters were used to allow only radiation between 2800 and 4000Å to reach the specimens. It is generally assumed that the more intense the radiation the greater the acceleration of the effects produced. This is probably true, but the relationship is not directly proportional. Thus, doubling the intensity does not cut the time required to produce a given effect in half; the factor will vary depending on the plastic. This is attributed to the fact that the degradation reactions generally proceed by free-radical mechanisms.

We realize that the above information does not answer your questions, but it is the best that can be done in view of our present limited knowledge on this subject.

Strength Tests for Plywood

Is there a way of comparing the knife delamination test with mechanical adhesion strength for plywood? We applied a knife test to two plywoods, but it was difficult to determine whether the glue line was weak, or whether the timber was stronger than the glue. Mechanical strength tests answered the question: in the first test, the strength was 300 psi with 0 per cent wood failure—the plywood was unsatisfactory; in the second test, the strength was 450 psi with 0 per cent wood failure—the plywood was satisfactory. How can the knife test be correlated with the mechanical test?

● In glued wood joint tests, when high percentages of wood failure are not obtained, no matter what the test, the chances of delamination under laboratory cyclical exposure testing are likely to be high.

Wood expands and shrinks with changes in moisture content, which accompany

(*Continued on page 50*)

1960 Nominating Committee

IN ACCORDANCE with the Bylaws of the Society, which provide that the Board of Directors shall select a nominating committee for officers, the Board has appointed the members shown below to the 1960 Nominating Committee. Serving as *ex officio* members are the three immediate past-presidents: R. A. Schatzel, R. T. Kropf, and K. B. Woods. The committee will meet in February and will nominate for the offices of president, vice-president, and directors. Their selection will be announced in the ASTM BULLETIN before the official ballots are transmitted.

MEMBERS	ALTERNATES
J. K. Killmer, Bethlehem Steel Co.	Robert Sergeson, Jones & Laughlin Corp.
G. M. Kline, National Bureau of Standards	R. M. Berg, Union Carbide Chemicals Corp.
L. S. Crane, Southern Railway System	M. A. Pinney, Pennsylvania Railroad Co.
J. J. Allen, Firestone Tire and Rubber Co.	Simon Collier, Johns-Manville Corp. (Retired)
R. H. Carter, General Electric Co.	W. R. Willets, Titanium Pigment Corp.
N. L. Mochel, Westinghouse Electric Co.	G. H. Harnden, General Electric Co.

Schedule of ASTM Meetings

This gives the lastest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
Jan. 13	Committee E-16 on Sampling and Analysis of Metal Bearing Ores	Philadelphia, Pa. (Society Headquarters)
Jan. 14	Conference on Psychophysical Testing	Philadelphia, Pa. (Society Headquarters)
Jan. 18–19	Committee B-1 on Metallic Electrical Conductors	New York City (ASA Headquarters)
Jan. 18–20	Committee A-1 on Steel	Philadelphia, Pa. (Warwick Hotel)
Jan. 24–27	Committee D-19 on Industrial Water	Atlanta, Ga. (Atlanta-Biltmore Hotel)
Jan. 26	Southeast District	Atlanta, Ga.
Jan. 27	New York District	New York, N. Y.
Jan. 31–Feb. 5	Committee D-2 on Petroleum Products and Lubricants	Detroit, Mich. (Statler Hotel)
Feb. 1–5	**Committee Week**	**Chicago, Ill. (Sherman Hotel)**
Feb. 9	Southwest District	Houston, Tex.
Feb. 9–10	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	Philadelphia, Pa. (Sheraton Hotel)
Feb. 11	Southwest District	Dallas, Tex.
Feb. 15–17	Committee D-1 on Paint, Varnish, Lacquer, and Related Products	Washington, D. C. (Shoreham Hotel)
Feb. 22–24	Committee D-27 on Electrical Insulating Liquids and Gases	Washington, D. C. (Sheraton-Park Hotel)
Feb. 23–24	Committee B-4 on Metallic Materials for Thermostats and for Electrical Heating, Resistance, and Contacts	Washington, D. C. (Sheraton-Park Hotel)
Feb. 25–26	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Washington, D. C. (Sheraton-Park Hotel)
March 1	Committee E-13 on Absorption Spectroscopy	Pittsburgh, Pa.
March 1–4	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin Hotel)
March 7–9	Committee D-9 on Electrical Insulating Materials	Cincinnati, Ohio (Netherland-Hilton Hotel)
March 8–11	Committee D-20 on Plastics	Cincinnati, Ohio (Netherland-Hilton Hotel)
March 9–11	Committee C-16 on Thermal Insulating Materials	Charlotte, S. C. (Hotel Fort Sumter)
April 19	Western New York District	Buffalo, N. Y.
April 26	Detroit District	Detroit, Mich.
June 26–July 1	**Annual Meeting**	**Atlantic City, N. J. (Chalfonte-Haddon Hall)**

NEW ASTM PUBLICATIONS

Symposium on Microscopy

STIMULATED BY the advent of new instruments and techniques, ASTM Committee E-1 on Methods of Testing sponsored this symposium with the intention to cover most of the recent developments in light- and electron-microscopy and the effective application of this tool to laboratory research and industrial production. Another purpose of the symposium is to disseminate knowledge of progress and to emphasize the need for continuous refinements and improvements in microscopical techniques. The symposium also reviews the ascent of microscopy from its humble beginnings to its present stature and appraises its future possibilities in the quest for scientific knowledge. The contents include:

Introduction—F. F. Morehead
Measurement with Phase and Interference Microscopes—Oscar W. Richards
Performance Characteristics of Objectives, Eyepieces, and Illuminators for Microscopy—H. W. Zieler
Chemical Microscopy in the Optical Industry—Germain Crossmon
The Study of Opaque Minerals in Reflected Light—Eugene N. Cameron
Application of Electron Microscopy in the Petroleum Industry—H. M. Allred
The Electron Microscope in the Study of Minerals and Ceramics—Joseph J. Comer
The Structure of Synthetic Fibers—Robert G. Scott
Microscopical Studies of Failure in Polymers—Sanford B. Newman
Microscopic Evaluation of Cotton Finishing Treatments—Mary L. Rollins, Ines V. deGruy, Verne W. Tripp, and Anna T. Moore

STP 257, 168 pages, hard cover, price $4.75, to members $3.80.

Electrical Insulating Materials

Compilation of Standards, D-9

THIS EDITION contains 108 standards of which 46 are new, revised, or changed in status since the previous edition in 1957. While the majority of the standards in the compilation are the result of the work of ASTM Committee D-9 on Electrical Insulating Materials, a considerable number were formulated by other interested groups, notably Committee D-20 on Plastics. These have been included so that other material published by the Society of interest to those in the electrical insulation field can be found in this volume.

Among the topics covered are:

Insulating Shellac and Varnish
Effects of Radiation
Plates, Sheets, Tubes, Rods, and Molded Materials
Ceramic Products (Glass, Porcelain, Steatite)
Solid Filling, Treating, Encapsulating, and Embedding Compounds
Flexible Sheet, Tape, and Tubing
Insulating Papers
Mica Products
Magnet Wire Insulation
Electrical Tests
Servicing Units and Conditioning Methods
Plastics for Electrical Insulation
Rubber Tape and Electrical Protective Equipment
Textile Materials for Electrical Insulation
General Test Methods

ASTM Standards on Electrical Insulating Materials, 792 pages, hard cover, price $8.75, to members $7.00.

Properties of Steels at Elevated Temperatures

Special Combination Offer

THREE CLOSELY related publications, prepared under the auspices of the ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals, are now being offered at a special combination price. Total regular price for the three has been $13.25 ($9.45 to members). Special price for all three is now $10 ($8 to members). The publications are:

Elevated-Temperature Properties of Carbon Steels, STP 180, 68 pages.

This volume includes data for tensile and yield strength, elongation and reduction of area, stresses for creep rates of 0.0001 and 0.00001 per cent per hr, and rupture strengths for 100, 1000, 10,000, and 100,000 hr.

STANDARDS COMMITTEE MEETS AT HEADQUARTERS

Members of the Administrative Committee on Standards are pictured at their October 2 meeting at ASTM Headquarters. From left to right: W. A. Kirklin, I. V. Williams, F. W. Reinhart, R. E. Hess, Miss Betty Preston (secretary to Mr. Hess), J. H. Foote (chairman), J. L. Menson, M. A. Pinney, S. A. Rosecrans, and G. H. Harnden. Not in the picture are L. J. Jacobi and J. B. Rather, Jr.

Supplements to Book of Standards: 7 of 10 Parts Now Available

The 1959 Supplements to the 1958 Book of Standards are being published in ten parts in heavy paper covers. Their 2700 pages include the new and revised standards and tentatives adopted or accepted at the 62nd Annual Meeting or by the Administrative Committee on Standards. Seven of the ten parts are now available; the remaining three Parts, 5, 7, and 9, will be available before the end of the year.

In the following list, the parts available now are shown in boldface type.

Part 1—Ferrous Metals (Specifications)
Part 2—Non-Ferrous Metals (Specifications), Electronic Materials
Part 3—Methods of Testing Metals (Except Chemical Analysis)
Part 4—Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils
Part 5—Masonry Products, Ceramics, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests
Part 6—Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather
Part 7—Petroleum Products, Lubricants, Tank Measurements, Engine Tests
Part 8—Paint, Naval Stores, Aromatic Hydrocarbons, Coal and Coke, Gaseous Fuels, Engine Antifreezes
Part 9—Plastics, Electrical Insulation, Rubber, Carbon Black
Part 10—Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes

Materials covered are: killed carbon steel (0.18 to 0.24 C), ASTM A 201 Grade B plate steel (0.24 C max), ASTM A 106 Grade B pipe steel (0.30 C max), killed carbon steel (0.27 to 0.58 C), aluminum-killed steel, open steel (rimmed or capped), and miscellaneous carbon steels (limited data available).

Properties are given in graphical form and supplemented by copies of original data sheets from those contributing the data.

Elevated-Temperature Properties of Wrought Medium-Carbon Alloy Steels, STP 199, 128 pages.

This report contains a graphic summary of the elevated-temperature strength data for medium-carbon alloy steels. It includes summary curves for tensile strength; 0.2 per cent offset yield strength; per cent elongation and reduction in area; stresses for rupture in 100, 1000, 10,000, and 100,000 hr; and stresses for creep rates of 0.0001 and 0.00001 per cent per hr (1 per cent in 10,000 and 100,000 hr). Data for 27 steels representing approximately a dozen alloy types are given. Data are also included for a few miscellaneous low-carbon alloy steels.

Elevated-Temperature Properties of Chromium Steels, STP 228, 124 pages.

This report is a graphical summary of the elevated-temperature strength properties of chromium steels. It includes data on tensile strength, yield strength, elongation, rupture, and creep properties. Twenty-three alloys are covered, ranging from 12 to 27 per cent chromium.

Textile Materials

Compilation of Standards, D-13

The many ASTM standards developed by Committee D-13 on Textile Materials cover the widely used products of this industry. They provide methods of tests, tolerances on textiles which assure good delivery on contract, and specification requirements—standards of quality.

The 1959 edition contains 134 standards, of which 23 are new, revised, or changed in status.

Included are terms, depositions, specifications for testing machines, methods for humidity testing, sampling, interlaboratory testing, quantitative and qualitative analysis, resistance to insect pests and microorganisms, fibers, yarns, threads, and cordage. Also included are standards for fabrics, nonwoven fabrics, hosiery, carpets, tire cord, asbestos textiles, bast and leaf fiber textiles, kraft yarns, cotton textiles, glass, man-made fiber, and wool textiles. In addition there are 15 extensive appendices.

This compilation provides in compact, convenient form, data and information of great importance to all who deal with textile materials.

ASTM Standards on Textile Materials 928 pages, hard cover, price $8.50, to members $6.80.

Expanding Horizons

Man is able to look ever deeper into space and deeper into the molecule. He is able to measure bigger things and smaller things than ever before. Therefore he needs, at the same time, bigger numbers and smaller numbers to report what he sees and measures.

In 1958, the International Committee on Weights and Measures adopted four new prefixes for denoting multiples and submultiples of units. The National Bureau of Standards announced recently that it will use these new prefixes. ASTM Committee D-9 on Electrical Insulating Materials is already using the word "picofarad," abbreviated pf. In the following list, the four starred prefixes are the new ones.

Multiple or Submultiple	Prefix
10^{12}	tera*
10^{9}	giga*
10^{6}	mega
10^{3}	kilo
10^{2}	hecto
10	deka
10^{-1}	deci
10^{-2}	centi
10^{-3}	milli
10^{-6}	micro
10^{-9}	nano*
10^{-12}	pico*

Directory of Laboratories Now Being Compiled

THE 11TH edition of the unique directory, *Industrial Research Laboratories of the United States*, is now being compiled and will be published in mid-1960. Published periodically by the National Academy of Sciences–National Research Council, the directory provides government and private organizations engaged in research and development with a convenient catalog of the nation's laboratory facilities.

The price of the volume is determined by the cost of publication alone. NAS–NRC is a private, nonprofit organization of scientists dedicated to the furtherance of science for the common welfare.

More than 25,000 questionnaires have been mailed in search of data for the directory. A cut-off date of Feb. 1, 1960, has been set for their incorporation in the 11th edition; all responses received after that date will be held for a later edition. Publication will follow hard upon the deadline to assure maximum value to the users.

As in the past, the directory will list only nongovernmental laboratories devoted to industrial research. "Research" is taken to include industrial development work on processes and products as well as fundamental and applied research. In addition, laboratories concerned primarily with routine testing and control, but conducting research activities, will be listed.

There is no charge for listing in this directory. Any research organization that has not received a questionnaire but wishes to be included should inform Walter M. Whitlow, Editor, *Industrial Research Laboratories*, National Academy of Sciences–National Research Council, 2101 Constitution Ave., N. W., Washington 25, D. C.

Nondestructive Testing Conference in Japan

THE THIRD INTERNATIONAL Conference on Nondestructive Testing, organized by the Science Council of Japan in cooperation with the Japanese Society for Nondestructive Inspection, will be held at **Sankei Kaikan, Tokyo, March 15–18, 1960,** and at **Mainichi Kaikan, Osaka, March 21.**

The purpose of the conference is to exchange information on the latest developments in scientific research and industrial application of nondestructive testing in various parts of the world and to improve techniques in this field.

The conference will also deal with problems of international cooperation, with the long-range view of establishing international standards in nondestructive testing.

Several members of ASTM Committee E-7 on Nondestructive Testing, including Vice-Chairman C. H. Hastings, are helping to prepare the program. The work of Committee E-7 will be reported at the conference.

Further information about the conference may be obtained from: The Secretary, Organizing Committee, Third International Conference on Nondestructive Testing, Science Council of Japan, Ueno Park, Taitoku, Tokyo, Japan; or C. H. Hastings, Chairman, International Relations Committee, Society for Nondestructive Testing, 147 North Ave., Weston 93, Mass.

Management's Changing Responsibilities*

By HOWARD K. NASON[1]

The modern isolationism of management behind its factory fences must end. Our very survival may depend on management's coming to realize that it can no longer ignore the sociological implications of its decisions.

SOMETIME within the past twenty years, according to Peter Drucker,[2] we passed largely without realizing it, from the "modern" age into a new and as yet nameless era whose characteristics mark it as a major new epoch in civilization. Change, irreversible change, is now accepted as the normal situation. Time and distance have been virtually eliminated as barriers to communication. Innovation is now a "controlled, directed, and purposeful human activity."

Profound though the implications of these changes may be to society and to technology, I should like to restrict this discussion to an examination of their effect on the management of our technological civilization. This examination will spotlight the changing responsibilities of management. Especially, let us consider the three areas that I shall designate as "The Practice of Management," "The Concept of Management," and "The Scope of Management."

The Practice of Management

Not so long ago, a manager was the member of an enterprise who knew exactly what needed to be done and who demonstrated to others exactly how to do it. The establishment of objectives, the evaluation of performance, and the apportionment of the inevitable rewards of success or penalties of failure were involved then, as now, though admittedly on a much more direct and informal basis. Working groups generally were small, and interpersonal relationships tended to be direct and forthright. The "span of control" was limited.

Today, management must organize groups into complexes for the accomplishment of complicated tasks, the control of large and far-flung organizations, the coordination and planning of multi-objective enterprises, and the extension of the management function into government, agriculture, and social organizations.

In the course of this effort, we seem to be uncovering evidence that there must always exist a dualism between organized effort and individual fulfillment, and that maximum efficiency of the former may be antithetical to maximum realization of the latter. Prof. Hilbert Schenck, Jr.[3] calls specific attention to the effect of this dualism on the engineer, who on the one hand prefers to work on strictly technical matters, yet on the other hand wishes to be considered a manager. The provision of the dual requirements of creative atmosphere and status is one of the most important responsibilities of technical management today.

From this we might conclude that management's task has changed from that of achieving maximum efficiency, and presumably maximum personal satisfaction, on the part of each member of a group, to that of recognizing and attaining maximum efficiency for the over-all "system," or organization, while salvaging as much as possible of each indivual's willingness to contribute his constructive effort.

I do not think that we can be satisfied to accept this as the necessary final state; as technical managers we must be responsible for further development, for change and for innovation, to the end that the maximum of individual effort may be used efficiently by the organized system and that the maximum return in individual satisfaction through pride, recognition, and reward of accomplishment may be realized.

The Concept of Management

A characteristic of the transition period in which most of us have spent our adult lives is the rate of change of our environment. To say that our technology is in a state of explosion is already a cliché. J. D. Williams[4] points up the rate of change to which we have become accustomed by expressing time in units of normal life spans. In these terms, Gutenberg's invention of printing came only seven life spans ago, and Newton could have enunciated his *Principia* to us through the mouths of only four men. We have lived only two life spans with the steam engine and the lathe, and only one with the internal combustion engine. Nuclear fission came into being as a source of power less than a fifth of a life span ago; yet, symptomatic of our acceptance of change as normal, it took us less than ten years to become quite blasé about it. It has taken only two years to become equally casual in our acceptance of satellites and space travel.

Another measure of the rate of change of our technology is provided by Sir Charles Darwin,[5] who points out that of all of the large quantities of minerals which have been mined since man first began to take them from the earth, half have been extracted since 1923. Thus, the extraction of coal, oil, copper, and the like during the past 35 years matches "the whole of human history in this matter."

Energy production is another criterion of technical development. Today's U. S. capacity of electrical energy is 140 million kw. E. H. Krieg[6] predicts this will reach 370 million kw by 1979.

Or here is another way to look at it. More than 90 per cent of all of the scientists and engineers who have ever existed are alive today.

The point that I wish to make from this is that management today lives in an era of bewildering plenty. Technical innovation has not only placed new tools at our disposal, it has made survival dependent upon our intelligent use of them. New energy sources, new materials, new techniques, resources, all must be employed effectively. New tools, such as the electronic computer, are helping management to assimilate the flow of information needed for its decisions. In fact, some phases of management, as of other tasks in technology, are passing from an individual art to a state that meets Kelvin's criterion of measurability. Such a transition always is difficult to those concerned, but most of all for the practitioners whose "art" constituted their unique contribution and who cannot adapt themselves to a more impersonal quantitative situation.

---

* This is a condensation of an address presented at the Management Luncheon, Semi-Annual Meeting, The American Society of Mechanical Engineers, in St. Louis, Mo., June 16, 1959. It was published in the October issue of MECHANICAL ENGINEERING.

[1] Vice-president and general manager, Research and Engineering Div., Monsanto Chemical Co., St. Louis, Mo. Former Director of ASTM.

[2] Peter F. Drucker, "Landmarks of Tomorrow," Harper Bros., 1959.

[3] Hilbert Schenck, Jr., "The Discontented Engineer," *The Clarkson Letter*, Clarkson College of Technology, Potsdam, N. Y., Jan.-Feb., 1959.

[4] J. D. Williams, "Some Attributes of the Changing Society," The Rand Corp., Santa Monica, Calif., Dec. 15, 1958, (P-1579-RC).

[5] Sir Charles G. Darwin, "The Problems of World Population," Rede Lecture of 1958, Cambridge University Press, 1958.

[6] E. H. Krieg, *Industrial Research*, Vol. 1 [1], Jan., 1959, p. 42.

Time long since has passed when a da Vinci or a von Humboldt could encompass all knowledge. Yet, when many of us began our professional careers a generation ago we might reasonably have expected that our basic education in a field of specialization would serve us throughout our working life. This no longer is so; today, one's basic store of knowledge, unless continuously renewed by assiduous study, will become obsolete two to three times during a working lifetime, and the manager, who by necessity must generalize rather than specialize, will find this especially true.

The value of direct knowledge and experience *per se* as a basis for decision is decreasing. In the future, management more and more must use techniques and information that it does not really understand, and it must be sage enough to know when it can depend upon past actions and when it cannot. Grant us the wisdom to remove ourselves from key positions when critical introspection reveals that we are no longer capable of such adaptation.

No longer are we entirely free to choose a rate of change, either for ourselves or for any organization for which we are responsible. The initiative is not necessarily ours; pressures over which we have no control—technical, economic, political, social—may dictate in what direction and how fast we must move. At the turn of the century, an enterprise that stagnated still might survive a generation of nonmanagement, or perhaps even two. Today, five years can ruin an enterprise—or a civilization. Thus, today's concept of technical management requires, first, that we recognize what is happening to us and that we no longer are completely masters of our own destinies. We must continually revaluate, reassess and reorient as needed to remain at least abreast, and preferably ahead, of the tide of technological change.

The Scope of Management

The rush of technology is irresistible and leaves management no choice but to use it effectively or be swept away by it. Political and social tides, fed by the flood of technology, exert pressures that management can ignore only at the peril of perishing under them. These pressures, which we might formerly have considered outside the scope of management, must be contained, or where uncontainable, adjusted to, if the American way of life is to retain a semblance of its present form.

The most obvious example of such pressures is the Communist tide, which certainly is running full in most of the world today. Yet, how appalling is our ignorance of its roots and intentions, though its founders and present leaders have clearly expressed them in writing for all to read and have never yet deviated from them. We continue to deal from a base of ignorance. Education to the nature of Marxist-Leninist Communism, and the employment of this knowledge in all of our administrative activities, not just in our political maneuverings, is crucial to our survival.

Another pressure is generated by our exploding population. The world population, which stood at about 300 million at the beginning of the Christian era had grown to only 500 million by 1700. In the two and a half centuries since then, this figure has grown to the present two and a half billion, and is increasing at the rate of 45 million per year.

To put this in perspective, this rate of increase means 100 thousand additional human beings in the world every 24 hours, clamoring to be fed, clothed, housed, and amused. By the end of this century, world population will be at least five billion. Something over 250 million of these will be Americans.

Today, Western civilization stands on a relatively small island surrounded by a fierce and hungry horde whose numbers are increasing daily. Technology, by erasing time and distance, has enabled these people to know that poverty and starvation are not necessarily the normal states of life. All of them feel awakened needs and awakened hungers whose fulfillment cannot long be denied.

If we try to isolate ourselves in a world clamoring for more of life's necessities, we inevitably will be swept away by the burgeoning horde. Only by aiding the rest of the world to achieve a higher standard of living may we even

STANDARDS AT WORK

Courtesy Pan American World Airways

ASTM AND THE FOUR-ACRE ROOF

Jet-age design is apparent in this roof for the 10-million-dollar passenger terminal Pan American Airways is building at New York International Airport. Workers have just planted the American flag on the last of 32 giant roof beams to be raised into place. Each beam weighs 78 tons, is 240 ft long. From the air, they look like the spokes in a huge wheel, covering an area of four acres. The "cantilevered parasol" roof, of reinforced concrete, will sweep upward at its outer edge so that jet clippers can nose in under it for loading and unloading.

Each roof beam is supported on malleable iron castings atop concrete piers. The castings are ASTM grade 35018 ferritic malleable iron as covered in ASTM Standard A 47.

hope to survive. To ensure more for the rest of the world may require, sometime before the end of this century, that we learn to get along with less, but this may be the price of survival.

I have complete confidence that technology can solve the material aspects of these problems and that we can learn how to grow enough food for the world's needs, to produce enough raw materials or to create satisfactory substitutes for those that become exhausted, and to provide enough energy. Satisfying material needs, however, will not ensure our survival unless social and political progress can also be made. Is it not significant that already today we have in this country agricultural surpluses whose mere storage is an onerous burden to us, while three-quarters of the world exists with a daily caloric intake roughly two-thirds of that considered minimum for a normal life? The stores of surplus foodstuffs that we will have on our hands by the end of the current growing season will be sufficient to provide the additional thousand calories per day needed for a minimum nutritional level for all of the rest of the world. Yet, in the face of this abundance, we struggle in vain for a solution.

Piel[7] points out that want is a social problem and "no longer a challenge to technology, but to economics and politics." It is my contention here that management no longer can stand aloof from these broad problems, of which technology is but one facet. Rather, management, for enlightened self-interest if for no other reason, must take an active part in efforts toward their solution.

The resources of technology will play an important part in all phases of this program. The electronic computer, which has produced such great changes in our technology and in the management of it, also possesses tremendous potential for application to problems formerly considered incapable of mathematical evaluation. That our Russian competitors are well aware of these potentialities is clearly brought out by their highly competent program for the application of matrix mathematics in evaluating the performance of the Soviet economy and in charting economic paths for future growth.[8]

The final threat to our continued existence is, of course, the presence of two armed camps in the world, each capable of utterly annihilating the other in a matter of hours. John Williams,[4] with his great gift for clarification, points this up by saying that "it is a literal fact that from now until eternity no man on earth will ever be able to guarantee that he can breathe one thousand times before he dies by violence." This limited span of certainty is the time it takes for a ballistic missile to travel to us from the most remote point on the earth's surface. We cannot erase this capability. It is not possible to turn back the clock. The only thing that we can hope to influence is the probability, and our only weapons are economic, social, and political ones.

The point I am trying to make here is that management no longer can ignore the nontechnical consequences of its own efforts, but must increasingly be concerned with such implications. Thus, management must employ economic, social, and political data in its studies, and must join other informed and well-intentioned people toward the solution of our nontechnological problems. In other words, the next step is a further integration of our environmental "system" into an engineered system using every component most efficiently.

Just as we attack a technological or management problem at the most simple identifiable level, so we must attack this more complex problem at the nearest point where it can be grasped—our local environment. From here, we can proceed logically to the more complicated state and national "systems." Only if these are put in order can we have any hope of ever achieving an orderly system of worldwide scope. The understanding and acceptance of these changing responsibilities requires even keener intelligence than we now possess, and intelligence can be sharpened only by education. The areas demanding attention lie clearly marked before us, and this attention is a matter of urgency and concern. The time is now. Tomorrow will be too late.

[7] Gerard Piel, "The Revolution in Man's Labor," a speech at St. John's College, Annapolis, Md., April 9, 1959.

[8] *St. Louis Post-Dispatch*, May 23, 1959, p. 1.

Tool Engineers Announce Seminars

CREATIVE manufacturing ideas for increased production will be explored in the 1959–1960 series of seminars to be held by the American Society of Tool Engineers. Varying from one to three days in length, the seminars are spotted throughout the winter months, the last one being in April, 1960.

Topics to be covered include metal forming, cutting, and machining; numerical control; optical tooling methods; automation; plastic tooling; and measurement techniques. Further information can be obtained from Gilbert E. Seeley, ASTE, 10700 Puritan Ave., Detroit 38, Mich.

Papers to Appear in Future Issues of the ASTM Bulletin

A Reliable Technique for Measuring Brush Wear in an Atmosphere Containing Silicone Vapor—J. S. Axelson and F. M. Precopio, General Electric Co.

Methods for Determining Hardness, Abrasion, and Wear Resistance of Plastics—L. Boor, Military Clothing and Textile Supply Agency, U. S. Army.

The Langley as a Unit for Timing Outdoor Exposures—C. R. Caryl, Desert Sunshine Exposure Tests

A Practical Method of Classifying All Elastomeric Vulcanizates—N. L. Catton, E. I. du Pont de Nemours and Co., Inc., R. C. Edwards, Chrysler Corp., and T. M. Loring, Michigan Precision Molded, Inc.

Design of Metallurgical Laboratory Equipment for Processing and Testing of Reactive and Refractory Metals—A. L. Feild, Jr., and V. A. Peckham, Jr., Universal-Cyclops Steel Corp.

Control Testing for Separation of Lightweight Material from Aggregate—E. C. Higginson and G. B. Wallace, U. S. Bureau of Reclamation.

An Improved Method for the Determination of the Normal Consistency of Plasters—R. A. Kuntze, Ontario Research Foundation.

An Instrument for the Determination of Impact Sensitivity of Materials in Contact with Liquid Oxygen—W. R. Lucas and W. A. Riehl, Army Ballistic Missile Agency, Redstone Arsenal.

A New Technique of Calibration for Gas Permeation Measuring Apparatus—T. McAvoy, Hotpoint Co.

Improved NBS Abrasive Jet Method for Measuring Abrasion Resistance of Coatings—A. G. Roberts, National Bureau of Standards.

A Study of the Accelerated Aging of Vinyl Compounds in a Modified Testing Oven—Markus Royen, Apex Tire and Rubber Co.

Tests for Potential and Past Moisture Expansion of Ceramic Building Units—E. H. Waters, J. S. Hosking, and H. V. Hueber, Commonwealth Scientific and Industrial Research Organization of Australia.

Improvements in ASTM D 635 Flammability Test Method—G. E. Eysenbach and J. J. Gouza, Rohm & Haas Co.

Instron Attachment Permits Straightness Measurements on Fine Wire—R. C. Nelson and Russell H. Rhodes, Sylvania Electric Products, Inc.

Standardization in India

William R. Pabst, Jr., a long-time member of ASTM Committee E-11 on Quality Control of Materials, recently returned from India, where he served as an advisor on quality control to the Government of India under the United Nations Technical Assistance Program. Here, Dr. Pabst describes standardization in India, with emphasis on statistical and quality control activities.

The authority on standards in India is the Indian Standards Institution. Supported mostly by 450 or more member companies, its primary purpose is to develop and publish standards. The ISI has a beautiful new headquarters building in New Delhi and a growing library.

ISI committees bring together government, industry, and consumer interests, to prepare and approve standards. Committee meetings are held in many of the larger cities. So far, the ISI has developed and approved over a thousand standards, many of which are derived from existing British and American standards. Its staff director, Lal C. Verman, has taken a strong interest in international standardization particularly in the International Standards Organization.

A statistical group in the ISI has been organized under Dr. A. K. Gupta, who did his graduate work in statistics in the United States. Dr. Gupta's office participates in the development of the individual standards for commodities and materials, usually as secretary or staff member of the committee. The statistical office is also interested in the preparation of general statistical standards and is concerned with enforcement of the Indian Standards Seal.

The ISI Seal. Companies licensed under the ISI may be authorized to use the ISI seal on products which conform to established standards. Some 100 companies, whose products include copper wire, aluminum utensils, and plywood for tea chests, have been authorized to use the seal. Recently so authorized were some 20 manufacturers of plywood.

In using the seal, the companies agree to make tests and inspections in a specified way to assure conformance of products with the standards. The Institution verifies this conformance in two ways—one, by examining the manufacturer's records and quality control data at the plant once or twice a year, and two, by examining products purchased in the market. Lack of conformance may result in loss of the privilege of using the seal. So far, there is little indication of lack of conformance.

The advantages to the manufacturer of using the seal apparently lie in the demonstrated conformance to quality standards and possible price performance based on such quality. The consumer market in India has not yet, however, been highly educated as to the quality of products and apparently has not been very responsive to the use of the seal, despite efforts of the ISI to develop consumer interest in it. The result is that manufacturers of wire or utensils, for example, seem to produce a very small proportion of their items to standards under the seal. In plywood, where purchases are made by large tea companies and tea estate buyers, for use in tea chests for export, there may be a quicker recognition of this mark of quality and widespread use of plywood made under the seal. More or less universal use of the seal on products for the Indian market may require a long process of education.

The Statistical Office of the ISI arranges for collecting data on conformance and establishing procedures for assurance. The ISI is encouraging its members to attend courses in quality control in order to help them conform more easily to quality standards and to make for easier verification. It may be that requirements for an effective quality control system in the manufacturer's plant may soon be written into the agreement to use the seal.

Product Standards. Those product standards that I had an opportunity to review seem to differ in emphasis from many of the standards prepared in the United States. In the standards on glass jars for canning, for instance, explicit sampling plans are given in the standard as the basis for conformance. These sampling plans are taken from Mil Standard 105A, the U. S. military sampling plans for inspection by attributes. The specifications for quality of the individual jars contain such expressions as "must be free from defects," and "of high quality," thus impairing the technical worth of the standards and leaving no solid or uniform basis upon which the sampling plans can operate. The ISI is aware of these limitations and has undertaken action for improvement. On the whole, the commodity standards are not inferior to those in other countries where similar problems of material specifications are encountered.

General Statistical Standards. The Statistical Office of the ISI is now preparing a general set of sampling tables for use in Indian standards. This work is being done in cooperation with the Indian Statistical Institution. A preliminary draft has been prepared; when completed it is likely that it will be used in place of such other standards as Mil Standard 105.

The Indian Standard 297 is essentially a redraft of the American Standard on quality control (Z1.1–1958). It serves a very useful purpose and is widely used for training.

The Indian Standards Institution is playing an effective role in the industrialization of India. Its fabric of standards is developing. It is providing training in the use of standards and encouraging interest in quality control techniques. It has gone far in the theory of statistics and their use in standards. A long period of education will be needed, however, to develop consumer support in making quality standards effective.

My primary work in India was in advising Indian industry in the use of quality control methods for increasing productivity. During my year there, I visited over a hundred plants and laid out positive programs for the use of quality control procedures in many of them. The results were encouraging; many of these companies reported increases in their productivity of from 5 to 15 per cent as a result of applied quality control. The Indian Standards Institution took a keen interest in this work.

1960 Committee Week

Chicago . . . February 1–5

River Skyline in Chicago, Host City for 1960 Committee Week

The 1960 Committee Week will be held during the week of February 1 to 5, 1960, in Chicago, with the Hotel Sherman as headquarters. At this meeting, some 300 committee meetings will be held during one week and in one place to enable our members to take care of much of their committee work with just one trip. The Chicago District Council, hosts for the 1960 meeting, is arranging as a social breather in the week of committee work a dinner, which will be preceded by a cocktail party. A portion of the cost of the dinner and the entire cost of the preceding cocktail party and entertainment are being subsidized by the Chicago District Council.

Featured speaker and guest of honor at the dinner will be Mr. John N. Ott, a pioneer and leading authority in the field of time-lapse photography. Mr. Ott, who at one time did work for Walt Disney Studios, is now a research consultant to General Electric Co. and to Johns Hopkins Hospital. His talk will, quite naturally, be illustrated by time-lapse motion pictures, which have the striking ability to condense time, thereby speeding up slow-moving processes so that they occur in minutes, rather than hours or days.

Committee Meetings

The committees that plan to meet during Committee Week are listed in the box below. The time for each meeting has been tentatively outlined in *Circular Letter No. 321*, mailed to our members on December 4. This letter was sent to all ASTM individual and company members and to nonmembers who represent company memberships on ASTM committees. With the letter were a hotel reservation blank and information concerning committee meetings, technical programs, and dinner. The official call for the committee meetings, however, must come from committee officers.

Has your hotel blank been returned?

While more than an ample number of sleeping rooms has been committed by the headquarters hotel, there is a limit on how long these rooms can be held without reservation. Our commitments with the hotel guarantees nothing after January 15.

Are you arriving on Tuesday?

The usual pattern of 3-day meetings—Monday-Tuesday-Wednesday, Wednesday-Thursday-Friday—tends to produce a peak attendance on Tuesday night. Committees whose meetings start on Wednesday have been asked to hold their first meeting in the late morning or early afternoon to allow their members to arrive in Chicago Wednesday morning, when sleeping accommodations being vacated by ASTM members are available for new arrivals. Thus the possibility of being sent to "nearby" hotels unnecessarily is avoided. Please try to avoid the Tuesday night peak!

Dinner Tickets

To avoid the need for a crystal ball and to provide the basis for a reasonable engineering guess, *please* fill in your advance order for dinner tickets. A guarantee must be given to the hotel on **Monday, Feb 1.** Attendance will be limited to 400.

Panel Discussion on Appearance Of Aluminum Surfaces

On Thursday morning of Committee Week, Committee E-12 on Appearance will sponsor a panel discussion on color and gloss of anodized high-silicon architectural aluminum alloys. All those interested are welcome to attend and to take part in the discussion. A description of the Committee's efforts in this field is given on page 33.

These Committees Are Scheduled to Meet in Chicago . . .

As this Bulletin goes to press, the committees listed below have indicated that they will meet in Chicago. The *official call* for each meeting will come from the officers of the committee.

A-3 on Cast Iron
A-5 on Corrosion of Iron and Steel
A-6 on Magnetic Properties
A-7 on Malleable-Iron Castings
A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys
B-8 on Electrodeposited Metallic Coatings
B-3 on Corrosion of Non-Ferrous Metals and Alloys
B-6 on Die-Cast Metals and Alloys
B-7 on Light Metals and Alloys, Cast and Wrought
B-2 on Non-Ferrous Metals and Alloys (subcommittees only)
C-7 on Lime
C-8 on Refractories
C-11 on Gypsum
C-12 on Mortars for Unit Masonry
C-15 on Manufactured Masonry Units
C-22 on Porcelain Enamel
D-4 on Road and Paving Materials
D-5 on Coal and Coke
D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses
D-11 on Rubber and Rubber-Like Materials
D-16 on Industrial Aromatic Hydrocarbons and Related Materials
D-24 on Carbon Black
D-25 on Casein and Similar Protein Materials
D-26 on Halogenated Organic Solvents
E-1 on Methods of Testing (subcommittees only)
E-4 on Metallography
E-5 on Fire Tests of Materials and Construction
E-6 on Methods of Testing Building Constructions
E-7 on Nondestructive Testing
E-9 on Fatigue
E-12 on Appearance
E-15 on Analysis and Testing of Industrial Chemicals

The Problem of Measuring Appearance of Aluminum Surfaces

During ASTM Committee Week, February 1–5, 1960, Committee E-12 on Appearance will sponsor a panel discussion on color and gloss of anodized high-silicon architectural aluminum alloys. The task facing Problem Subcommittee 4 of Committee E-12, which was organized in June, 1958, to work in this area, is here discussed by its chairman, R. V. Paulson, Kaiser Aluminum and Chemical Corp.

DIFFICULTY in matching appearance of anodized, high-silicon, aluminum building products has been experienced by major aluminum producers, fabricators, and architects. Each aluminum producer has a matching procedure for use or guidance of its customers. These procedures are similar, but trouble arises because they are not identical.

Task Group 4, Committee E-12 on Appearance, was organized in June, 1958, with a threefold purpose:

"To prepare recommended standard procedures for measurement of color and gloss of anodized high-silicon architectural aluminum alloys, colored aluminum surfaces, and characterization of mill produced aluminum surfaces."

The main purpose of the task group is to investigate problems associated with matching of high-silicon aluminum building products when they are anodized to shades of gray. This problem was discussed by a panel at a joint meeting of Committee E-12 and the Inter-Society Color Council in the spring of 1958.

It was felt that, since there were no standard procedures for measuring or specifying appearance of metal surfaces with colored transparent or semitransparent coatings,[1] an effort should be made to establish some. Any standard for measuring the appearance of colored, semitransparent, and transparent coatings would be used in the automotive and appliance industries and any other industry where control of color and appearance is a production problem.

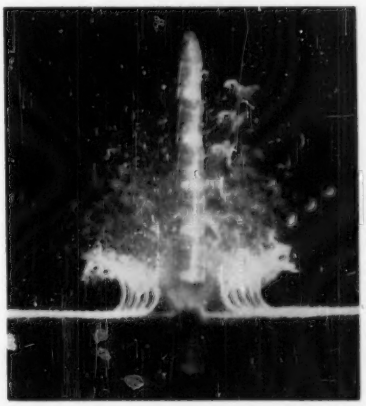
The third item in the subcommittee's objective was included to enable aluminum producers, distributors, and consumers to specify a particular finish, or degree of brightness, of noncolored aluminum surfaces by means of a name or a number, and to have this name or number mean the same thing to everyone in the aluminum industry. This third objective logically should include the measurement of brightness, image clarity, or specularity of bright clean coatings widely used in the automotive and appliance trim industries. For these measurements, the main difficulties appear to be instrumentation and definition of terms.

In all parts of this committee's task the appearance of an article must be measured. Normally, the appearance of objects of the same shape may be specified in terms of color and gloss. However, with aluminum surfaces, there are several unique problems. One is linearity of the metal surface resulting from the rolling or extruding operations. The appearance of a plain or colored sample is influenced by whether the article is viewed parallel or perpendicular to the rolling or extrusion direction. Another cause of difficulty in appearance measurement is the wide range of gloss that may be encountered on aluminum articles. The gloss or shininess of aluminum surfaces may range from mirrorlike to mat. The gloss and linear texture of an aluminum substrate under a colored transparent or semitransparent film strongly interfere with color-measuring techniques that are satisfactory for paints, porcelain enamel, and the like. The linear texture in noncolored as well as colored aluminum surfaces will probably have to be indicated when specifying appearance of a colored transparent film on aluminum.

The ideal solution would be one specification system that would cover all ranges of color, gloss, and surface textures that might be encountered. Then, from a few simple measurements, the appearance of a surface could be numerically described. An approach to this has been made by Mr. Eric Barkman of Reynolds Metals Co., in a report prepared for the Aluminum Assn. Mr. Barkman proposed a seven-letter digit specification that includes surface treatment, gloss, and color. It is evident in applying Mr. Barkman's system to a wide variety of samples that instrumentation is a major problem. As it stands now, there are not adequate instruments to implement any such ambitious color or appearance classification system.

In view of the complexity and wide range of material covered in the stated objective, it is reasonable that this subcommittee's activities should be divided into three separate parts. Two of these parts should be handled by special committees of Task Group 4, and the third should be transferred to another subcommittee of Committee E-12.

First, in view of the specialized nature of the anodized high-silicon alloys, one group should work on a usable specification for these materials. With gray anodized high-silicon alloys, no color is involved. Perhaps a specification having a single measurement for lightness plus a measure of gloss would be sufficient. To the best of our knowledge, all primary aluminum producers have such a system that they are recommending to fabricators. One approach to solving this part of the problem would be to set up an exchange of anodized high-silicon panels to



A STUDY IN FRAGMENTS

Results of a new multiflash photo technique show what happens when a bullet pierces a taut string. Dr. Harold Edgerton of Boston flashed six separate exposures to get this picture on a single piece of film. Each flash was for $\frac{1}{1,000,000}$ sec, with about $\frac{1}{100,000}$ sec between exposures. White line on bullet shows clockwise rotation. Dr. Edgerton described this new technique at the recent annual conference of the Society of Photographic Scientists and Engineers in Chicago.

[1] For our purposes, we may limit the term "colored coatings" to mean transparent or semitransparent coatings on aluminum. The measurement of colored opaque coatings such as paints and ceramics is covered by existing ASTM standards.

determine, first, the reproducibility of instruments, and from the results to designate instruments that might be used for measuring the shade of gray. A standard method of measuring and reporting gloss and linearity would also be required.

A second problem group should be set up within Task Group 4 to find ways to measure the appearance of colored transparent and semitransparent coatings. One of the first requirements of this group would be to obtain samples actually used in industry for acceptance standards and to determine the degree of precision required in any given industry. This group would also study the effect of gloss and texture on color measurements.

The third portion of the statement of Task Group 4 objectives should be transferred to Problem Subcommittee 3 on Goniophotometry. Methods are needed for measuring and defining small gloss differences, particularly on high-gloss samples. Gloss and texture measurements must be related to visual appearance. This group would also require industry standards to determine the degree of precision required and would work very closely with the group working on color.

If the subcommittee is to accomplish its objectives, it needs to know specifically the requirements of industry. As industry becomes aware of the subcommittee's function, there will be no shortage of specific problems. Some of the larger organizations, such as automobile manufacturers, who accept finished parts from a number of subcontractors, are keenly aware of the need for an impartial, accurate method of measuring appearance for quality-control purposes. Our responsibility extends not only to the large end user but also to the finishing subcontractors in order that they will be able to control their processes to meet rigid instrumental acceptance standards.

In summary, the ultimate goal of this subcommittee is to prepare accurate, usable methods of appearance measurement. Any standard procedures developed by this committee, however, should be the result of specific problems submitted by industry.

Know Your Committee Officers

To better acquaint Bulletin readers with the men who direct the indispensable work of the ASTM technical committees.

Committee A-10 on Iron-Chromium, Iron-Chromium Nickel and Related Alloys

Chairman
L. L. Wyman
National Bureau of Standards,
Washington, D. C.

Vice-Chairman
M. A. Cordovi
The International Nickel Co., New York, N. Y.

Secretary
L. B. Fonda
General Electric Co.,
Everett, Mass.

Committee D-2 on Petroleum Products and Lubricants

H. M. Smith
Chairman
U. S. Bureau of Mines
Bartlesville, Okla.

R. C. Alden
First Vice-Chairman
Phillips Petroleum Co.
Bartlesville, Okla.

W. K. Simpson
Second Vice-Chairman
General Motors Corp.
La Grange, Ill.

Photo by Bachrach

W. T. Gunn
Secretary
American Petroleum Inst.
New York, N. Y.

Does Management Get Full Value from Purchasing?*

By MARK W. CRESAP, JR.[1]

A few months ago, the Committee for Economic Development published the following statement:

"Within the next 20 years—barring war, and assuming we manage our affairs with reasonable competence–we may expect to enter a period of general well-being never before considered attainable."

I believe that no purchasing agent will be able to function with full effectiveness in the next several years unless he understands the implications of that statement. I also believe that the purchasing agent is going to be one of the important forces helping to bring about this "period of general well-being."

There are three massive forces at work today that make change and growth inevitable for us. One is the increase in our population—we will be creating 800,000 to 1,500,000 new jobs each year. Two is our insistence on a rising standard of living—the average family in 1975 will have a disposable income of around $7100 a year, in terms of today's dollars. Three is the rising tide of technology–this year we will spend more than $10 billion on research, 20 times our pre-World War II expenditure rate. These are the times when a team of serious and sober scientists undertakes a project to determine whether time runs backward as well as forward.

To state it briefly, we are going to have more people, they are going to want more from us, and we are going to be able to give it to them.

These changes will have a profound effect upon business management. They will place heavier demands on the company executive, present him with new problems, and add major complications to the problems he already has.

If you are a purchasing agent, I believe it can be taken for granted that you will strive to make the fullest contribution of which you are capable. But, as I see it, there are two things that could reduce your effectiveness.

One of these depends on top management rather than on you. The questions must be asked: Will management expect enough of its purchasing people? Will it demand the full performance of which they are capable? Will it permit the purchasing agent to use his talents to the utmost?

Under ideal conditions, the purchasing officer participates in a project from its inception. He sits in with engineering, manufacturing, and marketing on the first decisions, beginning with design, choice of materials, and level of quality. He contributes his own experience, knowledge, and imagination; and he brings to the problem the rich technical experience of the company's suppliers.

The situation is far less than ideal when the purchasing officer receives only a piece of paper containing specifications, scheduling, and amount. The higher decisions have already been made; only the price and supplier remain undetermined. He proceeds to buy the product. Being human, he wants to make a contribution to the transaction, and so he bargains for the cheapest possible price.

The second condition that could reduce your effectiveness as a purchasing agent will come about if you yourself downgrade the scope and importance of your work. It will come about if you submit to the greatest occupational hazard of your profession and buy solely or primarily on price—if you make your purchases without adequate consideration of the quality factors that determine ultimate net cost. I refer to such factors as performance, reliability, durability, consistent availability, efficiency in operation, technical suitability, operating economy, and, especially, technical and development service.

Management will always look to you to buy at low unit prices—it takes this part of your work for granted. But it will require far more than that in the future. It will demand a creative cost reduction program. One of the most valuable services you can perform is to make the rich technical knowledge and experience of your suppliers work for your company. You can benefit from your suppliers' expenditures on research, development, and engineering. You can multiply your own effectiveness in proportion to their skills and facilities.

The company that does not pick a supplier with a research and development program—the company that buys purely or predominantly on price—closes itself off from the finest reservoir of talent available in America. Eventually, as the cumulative effect builds up, its product lines lose individuality and prestige, and price becomes its only weapon in the battle against more progressive competitors.

In making our purchases at Westinghouse, we try to be as prudent as the housewife in the supermarket; we want every dollar to count. But price is only one of the factors involved when we go shopping. We recognize that there are mutual benefits to be derived from the research and development programs of our suppliers. We assign a definite value to such work. We accept the fact that we must help to pay the costs of such work, just as we would expect to pay for some special service performed, say, on delivery. We are willing to put a dollar sign on values which do not appear in black-and-white on the cost sheet, but which we know actually save us money.

It is logical for us to support those firms that "advance the art" in their field. We do not place these firms on the same price level with firms that have little in the way of engineering resources, do little or no research work, and seldom improve their products except by adapting innovations introduced by their competitors. We know that to place these companies on an equal price level will ultimately weaken the creative abilities of those which are foresightedly assuming substantial research and development costs.

It is the objective of your company to stay well ahead of its competition. In attaining this objective, why shouldn't you look upon your supplier as your natural partner? Why shouldn't you use him as a member of a team to improve your products? On such a team, the purchasing people would be the chief communicators with the supplier—the eyes and ears directed toward a tremendous reservoir of knowledge, imagination, and ambition.

The experts tell us that this country will spent twice as much on research and development in the 1960's as we spent in the 1950's. Your suppliers will be spending a considerable share of the money. It is to your interest to see that some of it is spent in your behalf.

---

* Adapted from an address presented by Mr. Cresap at the 1959 convention of the National Association of Purchasing Agents, in New York.

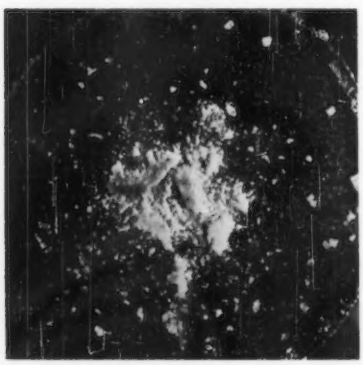
[1] President, Westinghouse Electric Corp., Pittsburgh, Pa.

Technical Committee Notes

Contacts Seen as Catalysts Result: Contamination

Surfaces of relay contacts sealed in cans under nitrogen atmosphere can develop deposits that impair relay performance. Dr. Saul Chaiken of Stanford Research Institute told the contacts subcommittee of Committee B-4, at their Pittsburgh meeting in October, that certain deposits have been traced to catalytic polymerization of organic vapors from the insulating materials sealed in the containers. Catalysts for the reaction are metals in the platinum group, including rhodium and palladium, which are often used for relay contacts because of their high conductivity and corrosion resistance. Another source of contamination is the metal tool used in forming the contact. Sensitive dye transfer paper can detect minute quantities of iron and copper left on the contact by the forming tool. Iron is especially undesirable because its oxide has low conductivity. The metallic contaminant can be easily removed chemically.

Offending polymers identified. A number of common types of insulating materials were investigated to determine which were the most likely sources of polymerizable vapors. Silicone and epoxy glass laminates gave off the least amount of polymerizable vapors, with nylon and Formvar intermediate, and phenolic laminates the most objectionable. Mass-spectrograph analysis of the gases from these polymers showed acetone, benzene, butenes, and other organic compounds to be present in amounts from traces to more than 1 per cent.



THE CASE OF THE FOULED CONTACT

During five years of storage in stockpiled equipment, organic crystals formed on this palladium contact in a sealed relay. This is an extreme example of the slow deposition of organic material on contacts which may be causing contact failure in sealed relays for low-level use.

Pure hydrocarbons studied. Fundamental studies are in progress using pure hydrocarbons and contacts of gold, silver, palladium, and rhodium. Gold and silver are least sensitive to contaminants.

Dr. Chaiken described this very challenging investigation with enthusiasm. A number of scientific disciplines must be called upon to solve contact contamination problems. The work at the Stanford Research Institute is supported by contract with the U. S. Army Signal Corps.

Committee B-4 will expose a number of contact assemblies at ASTM exposure test sites. Contact resistance will be measured periodically; it is hoped also to obtain chemical analyses of the atmospheres at the test sites.

Thermal conductivity test needed. Subcommittee III on Thermostat Metals is studying various test methods for thermal conductivity. A promising method being developed by Westinghouse Corp. will be distributed for comment by the subcommittees.

Concrete Pore Structure

Pore structure, one of the newer areas of study in the field of concrete, has been prominent on recent agendas of Committee C-9 on Concrete and Concrete Aggregates. A proposed recommended practice for microscopic determination of air-void content and the specific surface and spacing factor of the air-void system in hardened concrete has now been accepted by the committee subject to letter ballot. At the meeting of C-9, held during the 3rd Pacific Area National Meeting in San Francisco, much activity was reported by the Subcommittee on Admixtures, which, in addition to recommending a revision of the Specification for Fly Ash (C 350), plans to make it a general specification for artificial pozzolans. The subcommittee is also actively developing specifications for retarding, accelerating, and water-reducing admixtures, with methods of testing for such products.

The Subcommittee on Radiation Shielding is extending its study to materials, other than the barites, which might be used as aggregate in shielding concrete. Specifications for white polyethylene for curing purposes, developed by the American Association of State Highway Officials and the Society of the Plastics Industry, are being reviewed as the basis for a possible ASTM standard.

Curing of Insulating Varnishes Explored

Thermosetting polymers, both as varnishes for impregnation and as plastics, are widely used for electrical insulation. Just where cure of these materials leaves off and aging begins was a recurring question at the panel discussion on cure of electrical insulating varnishes sponsored by Committee D-9 on Electrical Insulating Materials at its Cleveland meeting in September. J. S. Hurley, Jr., served as moderator for the seven-man panel; the entire audience took part in the discussion. Following a general introduction by W. E. Harvey, Chairman of Subcommittee I on Insulating Varnishes, M. Prober of General Electric Co. outlined a method that had been found successful for determining molecular weight of the portion of the molecule between crosslinks. The determination is based upon stress-strain characteristics and specific volume of a varnish film. Messrs. DiCerbo, Haughney, Gunst, and Kin next spoke in turn on epoxy, polyester, phenolic, and silicone varnishes, with K. N. Mathes providing the summation.

Mr. Mathes emphasized the importance of relating laboratory tests to service performance. He pointed out that one way to test for cure of a varnish is to test it on a high-speed armature—increasing the speed until it throws. Improperly cured materials will throw at a lower speed than fully cured materials. While Mr. Mathes did not object to the scientific approach, he pointed out that if they are to be of more than academic interest, scientific findings should be correlated with performance.

Cement Standards Changing

The use of additions as a grinding aid in the manufacture of portland cement has been recognized in ASTM specifications by referring to specific trade-name materials after extensive tests and review by Committee C-1 showed such materials to be harmless to the cement. With an increase in number of such materials coming forward for considera-

tion, it has now been felt advisable to develop an ASTM specification for nonharmful additions to cement. The proposed specification, approved in subcommittee, will now be circulated to the entire committee. A companion specification already published is the Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement (C 226). These actions were reported at the meeting of Committee C-1 held during the 3rd Pacific Area National Meeting in San Francisco.

The determination of the potential sulfate resistance of portland cement will now be covered in a proposed method of test accepted by the committee subject to letter ballot. This method involves the measurement of the expansion of mortar bars containing excess calcium sulfate, equivalent to 7 per cent SO_3 by weight of the cement.

Significant revisions in the specifications for portland cement (C 150) and for air-entraining portland cement (C 175) were approved for immediate adoption subject to letter ballot. Among other things, these changes delete the requirement for tricalcium silicate (C_3S) for types II, V, and IIa cements, add to Table II the heat of hydration requirements at 7 and 28 days for types II and IIa cements, and change the footnote to Table II to indicate that, if not otherwise specified, the compressive strength test only shall govern. The sponsoring subcommittee approved the combining of specifications C 150 and C 175, which will be presented to the committee at the next meeting.

A cooperative study including 15 laboratories is being conducted jointly by the Sponsoring Committee on Masonry Cement and Committee C-12 on Masonry Mortar. The studies will include the determination of strength, air content, and water retardation of masonry mortars.

Plastics Group Hears Dietz On Moscow Exhibit

Members of Committee D-20 on Plastics enjoyed an unexpected visit behind the scenes in Moscow via 3-D color slides shown by Prof. A. G. H. Dietz, as a special event of the four-day meeting in Cleveland last September. Professor Dietz, acting head, Building Engineering and Construction, MIT, conducted the tour along side roads and byways of the Russian capital, told what he had seen in the way of construction techniques and everyday Russian life.

Professor Dietz was in Moscow to supervise the completion of the plastics pavilion, which he had designed for the U. S. exhibit there last spring. He explained the novel design features of the large plastic structure, a network of

Workmen Prepare to Raise Another Roof Section for Plastics Pavilion of U. S. Exhibit in Moscow.

horn-shaped components. The "bell" of each horn was reinforced by a steel hub and radial arms. The structure was designed to withstand a 60-mph wind load; a prototype was built and tested with the propwash from a military airplane. Since the structure was to be removed before winter, it was not designed for snow loading.

Crack propagation. Plastics can be caused to fail at stresses much lower than the yield strength, according to J. A. Kies of the Naval Research Laboratory. Dr. Kies described experiments at NRL to measure energy to propagate cracks. As a result of this work, a tentative procedure has been drafted and is now being considered by a D-20 subcommittee for establishment as a tentative method.

Flammability test questioned. Members of Committee D-11 on Rubber have questioned whether the tentative test for flammability of plastic foams and sheeting (D 1692), approved at the Annual Meeting, applies to flexible polyurethane foams. The rubber committee's objection was discussed at some length by committee D-20, and data available so far do not support the objections. Both the plastics and the rubber committees have started investigations to throw light on this question.

Statistical Techniques. J. A. Zoellner, General Electric Co., told the plastics committee about some useful nonparametric techniques. These techniques, which do not assume any statistical distribution for the data, can provide information on the subject under investigation without the bias that might result from assuming normal distribution.

The new Subcommittee XII on Polyolefin Plastics held its organizational meeting in September. Sections have been organized covering polyethylene plastics, polypropylene plastics, test methods, and sample preparation and conditioning.

Polyolefins are under consideration also in the plastics film and sheeting subcommittee, where work is in progress to develop a specification for polypropylene film and sheeting. The subcommittee has been working on a specification for polyethylene film, but lack of adequate test methods has held up completion of this work. There is considerable need for such a specification, and to serve in the interim the SPI has had established a Commercial Standard for polyethylene film, CS-5438. One of the test methods needed for this material is a measure of gloss; toward this end Subcommittee IV on Optical Properties is planning a cooperative investigation of the problems of measuring specular gloss as covered by Method D 523.

How Slippery?

What happens to the slipperiness of a floor when sorptive mineral materials are used as a flooring compound? Committee C-23 on Sorptive Mineral Materials, at its meeting in New York City on October 22 and 23, asked itself this question, and decided that a performance type of test might be developed to answer it. The committee feels that in this field of materials there is a definite need for a group of performance standards. At its first meeting, a newly organized subcommittee reviewed a survey now in progress, from which it hopes to get suggestions that will assist in the development of possible standards. Industry will be asked what plant tests it now uses to evaluate materials.

The committee has made good progress in developing proposed methods of test of a laboratory nature for evaluating the significant properties of sorptive mineral materials. Four procedures have already been submitted to the Society covering sampling, free moisture, loss on ignition, and sieve analysis. Additional procedures were reviewed covering bulk density, oil absorption, dust content, breakdown in water, solubility in water, and mechanical breakdown. The committee is doing a very thorough job in establishing a firm background of test data by round-robin tests which are in various stages of completion. The properties of abrasiveness and fire resistance are also on the committee's schedule.

Committee Makes Bibliography on Test Methods Available on Request

A bibliography was prepared by a task group of ASTM Committee C-23 on Sorptive Mineral Materials to review existing test methods for sorptive mineral materials used for floor surface maintenance and safety. This is perhaps the only publication in this field that has attempted to abstract not only published, but also unpublished, litera-

ture as found in many industrial laboratories. The bibliography contains abstracts of all available information on test methods and apparatus. It includes not only the bibliographical abstracts but also a list of the literature reviewed and an index of the organizations that submitted test procedures.

It was felt that this contribution, originally for the benefit of Committee C-23, should be made available to those having an interest in the subject. A limited number of mimeographed copies of the bibliography are available upon request. Requests should be made to Mr. R. L. Shirley, secretary of Committee C-23, The Eagle-Picher Co., Insulation Div., 900 American Bldg., Cincinnati 1, Ohio.

Committee Reworks Concrete Pipe Specifications

Improvement in existing specifications for concrete pipe occupied Committee C-13 during its meetings on October 14–16, in San Francisco. A number of changes were accepted in the Specification for Reinforced-Concrete Culvert, Storm Drain, and Sewer Pipe (C 76) relating to the wall C design, permissible variations in dimensions as related to the covering over circumferential reinforcement, and minimum wall thicknesses for wall C designs. The Tentative Specification for Concrete Drain Tile (C 412) will now be recommended for adoption as standard without change.

The new Tentative Specification for Perforated Concrete Pipe (C 444) will be revised to change the required size of perforations from $\frac{1}{4}$ in. to not greater than $\frac{5}{16}$ or less than $\frac{3}{16}$ in. An addition to the rejection clause was approved which says that any spall greater than $\frac{3}{4}$ in. in diameter and $\frac{3}{16}$ in. deep caused by making perforations shall be cause for rejection. The new specification for rubber gaskets (C 443) was carefully reviewed, together with comments from various sources, particularly Committee D-11 on Rubber. Changes were recommended, including the addition of infiltration or exfiltration requirements as specified by the purchaser. The circulating hot-air oven method of accelerated aging was approved as a replacement to the oxygen pump method.

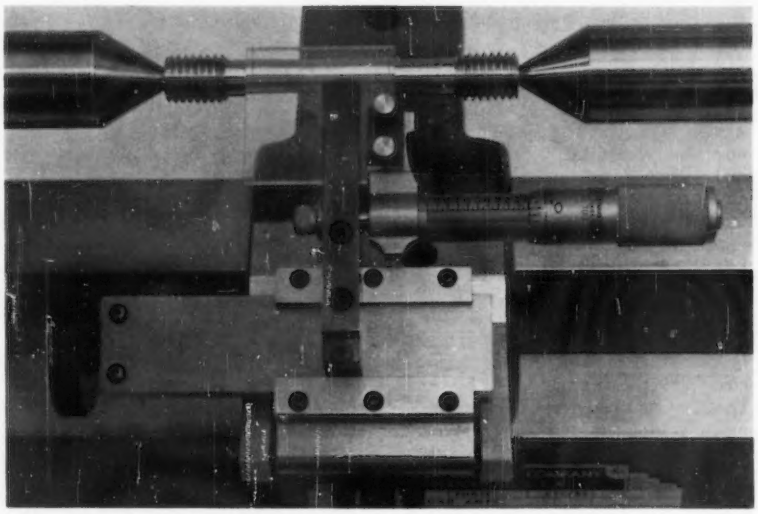
Trace Elements in Cathodes; Standards for Thermoelectric Materials

Electron tubes are here to stay and are improving all the time, despite the view held by some that solid-state devices will replace them. Some notable improvements in vacuum tube cathodes may be achieved by closer control of composition of cathode nickel, according to Herbert Kern of Bell Telephone Laboratories. Using highly purified nickel having no single impurity present in amounts greater than 50 ppm and most impurities present in quantities less than 10 ppm, definite amounts of reducing type additives were studied. In a typical nickel cathode, which is coated with barium oxide, reducing elements in the nickel react with the barium oxide to liberate quantities of electrons when the cathode is heated to operating temperature. Dr. Kern told Committee F-1 on Materials for Electron Tubes and Semiconductor Devices at its Skytop, Pa., meeting in November that highly purified nickel containing less than 1 per cent of either zirconium or magnesium had shown no significant decrease in emission and no detectable interface impedance after testing for 14,000 hr. Aluminum additive (0.028 per cent) contributed to peeling, developed interface impedance of 30 ohms per sq cm., and the emission failed at 8500 hr. Nickel with boron added (0.1 per cent) failed in 3000 hr. and pure nickel cathodes failed at about 1500 hr. It has been calculated that a trace of carbon is responsible for the emission in the pure nickel cathode. Dr. Kern pointed out that a calculation of the diffusion limited production of barium donor atoms came out in about the same order for the reducing additives in nickel as was observed in the tests. He urged that more attention be given to the trace elements in cathodes and particularly to the possible improvements that might accrue from the use of zirconium and magnesium additives in substantial absence of other trace elements. According to Dr. Kern, this report was a preview of the investigation scheduled for publication in part in the *Bell Telephone Record* and in the *Journal of Applied Physics*.

Semiconductor Group Expands Scope. On mandate from the F-1 Advisory Committee to investigate standards needs for thermoelectric materials, Subcommittee VI on Semiconductors established a working group on this subject. T. S. Shilliday, of Battelle Memorial Institute, outlined the present state of the art of thermoelectrics and named the areas where standardizing effects might be fruitful. A. C. Beer, also of Battelle, established a baseline for standardizing efforts in the field of intermetallics having possible utility for either solid-state devices such as transistors and diodes or for thermoelectric applications.

The problems of dissolved oxygen in silicon were discussed by Dr. Wolfgong Kaiser of Bell Telephone Laboratories. He pointed out that electronically active impurities are normally present in commercial silicon in quantities of

For More Precise Elongation Measurements



Recently developed by Alcoa Research Laboratories is this device for conveniently measuring elongation of fractured tension test specimens to the nearest 0.001 in.

A commercial bench center is provided with extra-long spindles, the tailstock spindle being spring-loaded to hold the specimen halves tightly together. A series of Lucite gage plates, each with two accurately spaced scribed lines for the gage length to be used, are available for mounting on the cross slide of the carriage. The specimen is mounted between centers and, with the micrometer zeroed, the left scribe line on the transparent gage plate is aligned with the left gage mark on the specimen. The gage plate is then moved to the right by the micrometer screw until the right-hand scribe line is aligned with the right-hand gage mark on the specimen. The micrometer then reads the extension to the nearest 0.001 in., and the elongation is computed to the nearest 0.1 per cent.

10^{13} to 10^{14} atoms per cu cm. Dissolved oxygen in silicon can be detected by infrared absorption, the oxygen showing an absorption peak at approximately 1100 $cm.^{-1}$ There was a strong, direct relationship between oxygen concentration and rate of donor formation. In order to check the infrared determination, oxygen may be determined by vacuum fusion analysis. It was pointed out in discussion that oxygen-free silicon crystals can be grown by floating-zone or by vacuum methods, and there was a question of the utility of the infrared technique for other than research purposes.

Many of the problems of semiconductors were being discussed in ASTM meetings for the first time, and in order to provide some long-term aim F. J. Biondi, vice-chairman of Committee F-1, suggested that the group direct its efforts toward the establishment of standard grades of semiconductor materials. This would of course require that standard test methods be developed for measuring properties and impurity levels. The establishment of specifications will require a very critical look at test methods, and when a proposed specification is written it will not be hard to find interested people to criticize it. According to Mr. Biondi, people would literally "come out from under rocks" to find fault with a proposed specification.

Thermal Insulation for Home Building Gets More Committee C-16 Attention

Work on specifications for thermal insulating materials for use in home construction was in increasing evidence at the fall meeting of Committee C-16 on Thermal Insulating Materials, held at Pocono Manor, Pa., September 28–30. A large number of specifications have been written by the committee primarily for industrial uses. This trend should be welcomed by architects and home builders who will be able to refer to ASTM specifications suitable for their needs. The first of these specifications is one for blanket insulation materials; a method of test is being prepared as a companion to the specification. The use of a foam plastic as a thermal insulating material is now recognized through a proposed specification under consideration. A testing program is providing the data needed for preparing a specification for insulating formboard. A proposed test method for structural insulating roof deck slab made from vegetable fiber is being circulated for comment.

Complete revision of the Method of Test for Thermal Conductivity by Means of the Guarded Hot Plate (C 177), one of the basic test methods in this field, is nearing completion. It is planned to include separate descriptions of the apparatus, procedure, and sample preparation for both the metal-surfaced and the alundum hot plates. A round-robin test series is being conducted to establish an upper limit on specimen conductance for rigid specimens tested on metal-surfaced hot plates.

The reliability of test methods for water-vapor transmission is the subject of four round-robin test programs with nine laboratories participating. A report on this work will soon be published. This work will lead to improvement of the test methods.

Test Methods for Clays And Glazes Studied

Two proposed methods for the determination of particle size of clays were discussed at the meeting of Committee C-21 on Ceramic Whitewares and Related Products, held at Bedford Springs, Pa., Oct. 1, 1959. The first of these uses an hydrometer to measure particles down to 2 μ and the second uses a centrifuge for particles below 2 μ. Other methods for clays include a colloidal procedure for determining organic content and a turbidimetric procedure for determining the soluble sulfate content.

Discussion of the latest draft of a test to determine lead solubility of glazes indicated that the relative efficacy of citric acid (lemon juice) *versus* acetic acid (vinegar) should be investigated. An interlaboratory test will be conducted to determine whether acetic acid can be used in place of citric acid which, although it dissolves lead more aggressively than acetic acid, is difficult to prepare as a standard solution.

Methods are being developed to test for alkali durability, detergent resistance, translucency, heat-shock resistance, and Knoop hardness.

An interlaboratory study is being conducted to determine the reproducibility of a kerosine method for determining the equivalent water absorption. This test has been used to obtain absorption values in 20 min that are practically equivalent to values obtained from the 100-hr water-soaking test.

Will Prepare New Method for Analyzing Cellulose Pulps

The results of an interlaboratory collaborative test on the accuracy of chromatographic techniques for analyzing refined cellulose pulps were reviewed at a meeting of Committee D-23 on Cellulose and Cellulose Derivatives in Atlantic City, N. J., on Sept. 16, 1959. Five mixtures of glucose, mannose, and xylose were analyzed by eight laboratories in the as-received condition and following simulated hydrolysis. In addition, similar analyses were made of the mannan and xylan content of five standard samples distributed by the International Committee on Cellulose Analysis (ICCA). The results indicate that the method can be quite accurate. A method based on this work will be prepared for publication within the year.

An interlaboratory study was made of the aniline acetate (D 1438), arcinol, and bromination methods for the determination of furfural in pentosan distillates using the ICCA standard samples. The report of this work indicates that the arcinol procedure is the most precise of the three methods. A revision of Method D 1438 based on this work was proposed.

A method to determine disperse viscosity as a measure of the molecular length of cellulose is being prepared. Additional procedures for the Methods of Testing Cellulose Acetate (D 871) and for the Methods of Testing Cellulose Acetate Butyrate (D 817) are also in preparation.

New Title and Scope For Committee B-8

At the meeting of Committee B-8 on Electrodeposited Coatings held in Philadelphia, Pa., on Oct. 16, 1959, the committee approved, for submission to letter ballot, an expanded title and scope for the committee. The new title: "Electrodeposited Metallic Coatings and Allied Finishes for Metals." The scope has been expanded to include electrodeposited, anodized, and chemically reduced coatings of all kinds. These changes are prompted by the transfer of Subcommittee VI on Anodic Oxidation of Aluminum and Magnesium Alloys from Committee B-7 to Committee B-8.

The recommended practice for preparation of nickel for use in electroplating with nickel was presented for committee action. This practice defines the new Duplex process, which has improved the weathering resistance and the appearance of nickel-plated parts.

A new atmospheric exposure program, No. 5, was approved. This program will determine the comparative performance of copper-nickel-chromium and nickel-chromium coatings on steel, using various coating thicknesses to determine what systems will lead to better performance of plated parts.

Credit where credit is due . . .

In the paper, "Municipal Incinerator Refractories Practice," by R. B. Engdahl and J. D. Sullivan, which appears in the September 1959 BULLETIN, we regret that the credit line for Fig. 2 is incorrect. That photograph, on page 53, should be credited to the **Department of Sanitation, New York City—Combustion Engineering Co.**

District Activities

NEW YORK

Of Meter Sticks, Atomic Clocks, And Elbow Joints of Kings

The standard unit of length was once the distance from the king's elbow to his finger tip. So says Robert D. Huntoon, Associate Director for Physics, National Bureau of Standards, and he ought to know. Speaking at the Oct. 22 meeting of the New York District, Dr. Huntoon described the current status of the basic standards in physical measurement, and in the process communicated to his audience some of his own fascination with the subject.

A distinct improvement on the king's forearm was the meter, which originally set out to be one ten-millionth of the quadrant of the earth from the North Pole to the equator, through Paris. At about the time of the French Revolution, surveyors set out to measure this, but with conflicts raging about, and what with all the political-boundary complications, the measurement left something to be desired. The meter wound up being a completely arbitrary unit, embodied in a platinum-iridium bar, kept in Paris.

Such arbitrary standards, Dr. Huntoon pointed out, leave one feeling somewhat insecure and temporary. Scientists at NBS, which is responsible for such fundamental standards in the United States, are establishing "independently reproducible standards," which are not only less arbitrary, but, on the whole, offer much higher accuracy.

To establish an independently reproducible standard, said Dr. Huntoon, one must be able to write down plans for constructing a black box and an experiment that someone else can build and perform, and from which he can obtain a measurement of an invariant quantity that can serve as a fundamental standard. There is no need to calibrate one person's measurement against another's—different values arise only from errors of observation, not from variations in the quantity being measured.

For length, for example, one might choose the wavelength of a certain radiation emitted by a given substance under given conditions. Then, anyone equipped to measure this could reproduce the standard; it would not be necessary for him to trot to Paris with his metal bar to see how the length of his bar compared with the length of the one in Paris.

Time is a bit trickier, said Dr. Huntoon. It being purely a subjective quantity, there can be no physical embodiment of a time standard. It can, however, be defined indirectly by use of the periodicity of certain natural phenomena. The rotation of the earth on its axis, or its repeated swing about the sun, are the commonest examples. Since the lengths of no two solar years are exactly the same, however, this is not a completely satisfactory time standard. Standards of much higher accuracy are now being obtained from "atomic clocks," that is, frequencies of atomic spectral phenomena. The cesium clock being prepared by NBS will be put into orbit about the earth for checking the stretching of the time dimension with velocity that is predicted by relativity theory.

NEW ENGLAND

Boston Meeting Hears LaQue on Corrosion

Addressing one of the best attended meetings in the history of the New England District Council, President F. L. LaQue discussed "What We Know and Don't Know About Corrosion." The joint meeting of the New England District and the Boston Section of the AIChE, held at the new Boston Museum of Science on Thursday, November 12, was attended by some 200 members and guests.

President LaQue said that much work in the field of corrosion must be done. The areas of uncertainty and ignorance appear to be as great as ever. Although a great mass of empirical knowledge has grown up during the years, a mechanism for corrosion still is lacking in many cases. Each kind of corrosion—galvanic, stress, cavitation—requires a different theory. Unfortunately, the theories are not universally applicable.

Predictions based on laboratory experiments can also be very misleading. Mr. LaQue cited several instances in which laboratory experimental data indicated that an alloy would be suitable for a certain type of application, whereas, in practice, it was shown not to be.

It has been relatively easy to explain what happens after corrosion has set in, but predictions or generalizations have proved to be misleading. From basic research in corrosion it is hoped

Twelve Seniors Receive Student Membership Awards

At its October 28 dinner meeting at the Hotel Lennox, the St. Louis District Council presented awards to twelve senior engineering students from four universities in the area. *Top left*, from Missouri University: students James E. Monsees, Joseph P. Fagan, and Lawrence Bollinger; H. D. Comins, professor of civil engineering; W. C. Magruder, chairman, St. Louis District Council. *Top right*, from Washington University: A. W. Brust, director of the Washington University Civil Engineering Laboratory; students Michael Kausch, John G. Manda, and Terry R. West; Don Fischer, dean of the School of Engineering. *Bottom left*, from St. Louis University Institute of Technology: Rev. Victor J. Blum, dean of the Institute; students Richard F. David and Tom J. McCartney; John McCarthy, head, Department of Civil Engineering. *Bottom right*, from Missouri School of Mines and Metallurgy: students Orville Hunter, Jr., Robert Liptai, Carl Van Sant, and Robert E. Farris; H. L. Furr, assistant dean.

AT NEW ENGLAND DISTRICT MEETING

Part of the head table in Boston (*left to right*), District Chairman R. H. Doughty, Fitchburg Paper Co.; A. S. Collins, AIChE, Godfrey L. Cabot, Inc.; ASTM President F. L. LaQue; C. W. Angell, AIChE, Artisan Metal Products Co.

that predictions about corrosion will be made possible. At present, the criterion is past experience.

The program was arranged by Dick Saunders, program chairman of the New England District, with the cooperation of the officers of the local AIChE Section. "A Preview of Winter Skies" was shown at the Museum's Hayden Planetarium. Following the social hour and dinner, brief introductions were made of the AIChE officers by Arthur S. Collins, chairman. Randy Doughty, chairman of the ASTM New England District, then presented New England District Student Awards to students from six local universities and colleges.

ROCKY MOUNTAIN

Tour of Air Force Academy Part of District Meeting

It is not often that our members are afforded the opportunity to hold a meeting at a location such as the Air Force Academy. The meeting, sponsored jointly by the ASTM Rocky Mountain District and the Denver Chapter of the Construction Specifications Institute on October 20, was a very interesting one in a number of respects. Those who attended gained a very excellent idea of the purposes and aims of the Academy from the address of welcome by Maj. General William S. Stone,

At Rocky Mountain District Meeting, Edward Merrill, Skidmore, Owings, & Merrill, Architects, addresses morning session on "Problems in Specification Writing for the Air Force Academy."

Academy Superintendent, and from guided tours of the laboratories and other buildings. There was also an opportunity for presentation of ASTM activities through a talk on "ASTM Specifications Applied to Government Contracts" by Walter Price, head, Engineering Laboratories, U. S. Bureau of Reclamation, and a talk by R. E. Livingston, planning and research engineer, Colorado State Highway Dept., Chairman of Specifications Committee, Highway Department, on "The Highway Engineer's Approach to Specification Writing." Associate Executive Secretary R. E. Hess discussed the various sources of research activities that enter into ASTM standards. Mr. Edward Merrill of Skidmore, Owings, & Merrill, the architects for the Academy, presented an interesting dis-

AT HEAD TABLE, DINNER MEETING, ROCKY MOUNTAIN DISTRICT.

From left, Col. Archie Higdon, professor and head, Department of Mechanics, U. S. Air Force Academy; R. E. Hess, associate executive secretary, ASTM; J. Stewart Stein, partner, Sobel & Stein, Architects, and president of Construction Specifications Inst.

cussion of the various problems encountered in the design and contruction of the Academy facilities, particularly the question of available time for providing the facilities when needed.

Two outstanding technical papers were presented by representatives of the Wright Air Development Center: "Adhesive Bonding Materials," by L. D. Richardson, Materials Laboratory; and "Unique Evaluation Facilities and Techniques for the Space Program," by V. DiBenedetto, Materials Laboratory.

At a dinner meeting held in the Ent Air Force Base Officer's Club in Colorado Springs, J. Stewart Stein, president, Construction Specifications Inst., and partner, Sobel and Stein, reviewed the history and accomplishments of CSI to date. ASTM President F. L. LaQue discussed some of the approaches toward a better understanding of the nature of materials.

PITTSBURGH

Rocket Ship Propulsion

"Propulsion Requirements of Space Vehicles" was the topic of a joint meeting of the Pittsburgh District, ASTM, and the Pittsburgh Section of the Society of Automotive Engineers. The meeting, held Tuesday, October 27 at the Mellon Inst., was addressed by Stewart Way, consultant, Westinghouse Research Laboratories.

Dr. Way considered the propulsion requirements for several proposed space missions, including satellite launchings, orbital shifts, lunar missions, and interplanetary flights. A number of proposed methods were discussed, including ion propulsion.

A graduate of Stanford University, Dr. Way received his Ph.D. in engineering from the University of Michigan. He started his career with the Douglas Aircraft Co. and held positions there and abroad before joining Westinghouse as a research engineer in 1935. A member of numerous societies and holder of many patents, Dr. Way teaches at the University of Pittsburgh at the graduate level.

Technical Chairman for the session was H. Kenneth Siefers, vice-president and general manager, United Oil Co.

WASHINGTON, D. C.

Labeling Laws Discussed

A panel discussion on labeling laws and the test methods used to support them was sponsored by the Washington District Council, in Richmond, Va., on November 12.

C. D. Baucom, Superintendent of Weights and Measures, State of North Carolina, described the procedure used in his state for checking gasoline delivery. Samples are taken from the delivery pump to test meter accuracy, and then the gasoline is subjected to ASTM tests for rating of motor fuels. ASTM tests are also used to test kerosine. Knotty testing problems are being encountered in the testing of liquid petroleum gas. Satisfactory sampling techniques have only recently been devised, and rating methods for the gases and their mixtures still present difficult problems.

R. C. Brinker, Supervisor of Paint Section, Dept. of Agriculture and Irrigation, Commonwealth of Virginia, discussed the Virginia paint law. This law requires that each paint label give the names and percentages of the ingredients and that all labels be registered and approved by the state. Labels with spurious claims or without a proper statement of ingredients are rejected. The test methods used are based on Federal specifications, ASTM methods, and some developed in the department. Mr. Brinker said that because of the rapid rate of new developments in the field, the ASTM methods are falling behind, particularly since they refer only to white linseed-oil paints.

Emanuel Kaplan, Chief of Laboratory, Baltimore City Dept. of Health, said that Baltimore law stipulates that the label for a paint containing more than 1 per cent lead must be so marked and must state that the paint cannot be used for anything that might involve children.

PANEL DISCUSSION IN RICHMOND

Addressing the group, Charles E. Couchman, director, Bureau of Industrial Hygiene, Baltimore City Health Dept.; *at left*, C. D. Baucom, superintendent, weights and measures, State of North Carolina.

SOUTHEAST

President LaQue Speaks on Materials Research

President F. L. LaQue addressed a joint meeting of the Southeast District and the Oak Ridge Chapters of the American Society for Metals and the National Association of Corrosion Engineers on "Research in the Materials Field." Emphasis was on metals.

The meeting was held at the University of Tennessee, Wednesday, November 18. Speaking from an extensive background of research and standardization work, Mr. LaQue discussed the importance of research as it affects our knowledge of materials, the role of research in standardization for materials, and its over-all impact on industry's ability to develop new materials for new uses as well as to apply old materials to a wider range of uses.

Arrangements for the meeting were made through the cooperation of Eugene E. Hoffman, representing the Oak Ridge Chapter of ASM, and ASTM Southeast District Chairman James A. Lee, Southern Brick and Tile Assn.

CENTRAL NEW YORK

The Future of Powder Metallurgy

NEITHER SNOW, nor icy roads, nor 100 miles of driving each way kept a group of about 15 from being among the 50 or so who attended the Central New York District Meeting at Schenectady, Nov. 18. After a tour of the new Metals and Ceramic Research Laboratory of the General Electric Co. at the Knolls, Schenectady, dinner was served in the laboratory cafeteria. Following dinner, ASTM Vice-President Miles N. Clair, president, The Thompson and Lichtner Co., Inc., spoke on "What is Happening in ASTM Today?"

"ASTM is going forward," said Mr. Clair. "It is growing in members, in committees, in publications, in Staff, in space and building requirements, and in budget requirements to serve members and industry." Mr. Clair described many of the problems now under study by the Society's Long-Range Planning Committee.

The main address of the evening was presented by Fritz V. Lenel of Rensselaer Polytechnic Inst. on "Wrought Products by Powder Metallurgy."

"In the past," said Dr. Lenel, "powder metallurgy has been best known as a method of fabricating machine parts to close dimensional tolerances at a cost less than that of competing methods. From an historical point of view, however, it was not the production of parts, but the production of ingots which were subsequently rolled into sheet or drawn into wire which gave powder metallurgy its start, beginning with Wollaston's technique of making platinum sheet from powder early in the 19th century and continuing with Coolidge's development of tungsten wire from powder early in this century.

"In the past few years the production of wrought products from powder has found renewed interest," continued Dr. Lenel. He predicted that powder metallurgy will be used increasingly for (1) products of closely controlled composition and purity, (2) products with structures and properties not attainable by fusion metallurgy, and (3) more economical wrought products.

DETROIT

Bates Extends Successful Six-Year-Old Prediction

"BY 1970, THE 'compact car' will be the normal car in this country." So predicted ASTM Vice-President A. Allan Bates, vice-president of research and development, Portland Cement Assn., at the Detroit District Meeting, Nov. 19. This is an extension of a prediction made 6 years ago by Dr. Bates. "By 1960," he said then, the automobile manufacturers of America will be producing small cars comparable in size to the common European automobiles." The newest prediction, made in the nation's automobile center, was one of a number of evocative remarks made by Dr. Bates in an absorbing talk dealing with our prime energy sources.

As we use up reserves of our traditional fossil fuels, said Dr. Bates, our sources of energy will change. Energy cost will be the important factor in making the family car smaller, although other factors such as space considerations also will have a bearing. As more energy is used and fuel reserves diminish, cost of producing energy will rise. It will then become economical to turn to other sources of energy and to other methods of using energy more efficiently. As the speaker intended, his thought-provoking comments stimulated much discussion and numerous questions from his audience.

PHILADELPHIA

Benefits of Materials Research

SPEAKING AT A NOV. 19 meeting of the Philadelphia District in Easton, Pa., ASTM President F. L. LaQue outlined several areas where materials research can extend engineering frontiers. It can be used, he said, to diagnose failures of materials in new environments, to develop materials for specific purposes, to create new materials in the hope that commercial applications can be found later, or to improve existing materials. In the quest for basic knowledge, the study of the properties of materials often gives unexpected results which may lead to the solution of long-standing problems.

PRESIDENT LAQUE SPEAKS AT EASTON

As examples of the benefits of materials research, President LaQue cited the use of Inconel to clad the rocket ship X-15. The metal was originally used in the turbine blades of jet engines. Other examples given were the new alloys to handle high-temperature, high-pressure steam for electric generators and the alloys for use in atomic aircraft engines.

An address of welcome was given by Prof. H. Maurice Carlson, director of engineering at Lafayette College, site of the meeting. Included in the day's activities was a tour of the engineering facilities of Lafayette and a dinner at which Student Award winners and faculty sponsors were guests of the Philadelphia District Council.

Cross-Pollination of Ideas

By Bruce W. Gonser[1]

There is nothing new in recognizing the interdependence of the sciences and the various branches of technology. Progress moves irregularly on a broad front. All of us recognize that a basic truth learned in one field can be, and frequently is, applied advantageously in an entirely different area. The important thing is to encourage and aid this exchange of ideas.

Some of the most useful ideas come from the most unexpected sources. Fluidized bed operations, for example, probably originated in the oil refining industry, then were adapted to the roasting and treatment of ores, to the recovery of metals from volatilized compounds, to the coating of both metal and nonmetal particles, and now are finding use in the drying of textiles and are being considered for applications in the food processing industry. Adhesives have grown up from the paper industry to the sealing of cans, to some uses in aeronautical construction, and recently to experiments in joining railway rails.

Technical men in the cement and concrete field would be interested in seeing a recent adaptation of a miniature concrete mixer to the making of some lead-base alloys. It was found to be admirable for dispersing through lead various solids that were wet by, but not dissolved by, lead. Likewise, the technology of the rubber industry has been used to incorporate magnetic particles into this flexible and readily-formed medium to give magnets of unusual characteristics.

The old Pattinson process for removing silver or bismuth from lead by repeated slow freezing cycles was revived in a beautifully refined manner some years ago as zone refining of metals. This was the key to extreme high purification of germanium, which led to the unfolding of the fast-growing semiconductor field.

While naming unusual developments, one should not neglect the paint, varnish, and lacquer industry. Recently, a representative of this industry in England, who should go down in history, suggested the use of a special clear, hard lacquer to coat the head and shoulders of statues that were favorite roosting spots for pigeons. There, as in this country, pigeons have been viewed with mixed feelings. Many unsuccessful attempts had been made by specialists in the field of bird control to keep the birds away from these hallowed areas. But the lacquer did! It seems that the hard glossy surface gave no traction whatever. When the pigeon came in for a landing he skidded—like a duck on ice. After a few passes, with resultant humiliating tail bumps, the pigeon sought easier roosts.

Of course, not all ideas from a specialist in one field are applicable in another. We are reminded of the production engineer's critical comment about the testing laboratory. "You could save a lot of time," he said, "if you used a double chuck in that tensile machine and pulled two test bars at the same time."

There are many examples of cross-fertilization of ideas that any of us can cite. The point is that research and advancement in almost any field can profit by the ideas, experience, and knowledge gained in another field. It pays, then, to move about and mix with men in other fields of work. In this connection, it is hard to imagine a more potentially useful medium for the exchange of ideas among men of diverse training than ASTM. Possibly the National Academy of Sciences and the National Research Council can claim a broader coverage of science, but for an easily accessible, practical working organization the coverage by the many committees of ASTM is most impressive. You are missing something if you don't take advantage of the opportunity to sit in at various committee meetings and attend some sessions outside of your own specialization.

Fortunate is he who can sit on the railing between two sciences and catch ideas from one side to toss rings around specialists on the other.

[1] Chairman, ACR; Technical Director, Battelle Memorial Institute.

Japanese Textile Trade Study Group

Members of the group who visited Society Headquarters, October 22, *left to right:* S. Asada, Ministry of International Trade and Industry, Japanese Government; H. Yamazaki, managing director, Japan Cotton and Staple Fiber Fabric Inspecting Institute Foundation; T. Shibata, chairman, Board of Directors, Textile Products Inspection Council, leader of the group; Mr. Takayama, interpreter; and T. Yanagizawa, managing director, Japan Export Sewing Goods Inspection Foundation.

Photographers Attention!

Plan to Enter the 1960 Photographic Exhibit

The 12th ASTM Technical Photographic Exhibit will be held in Atlantic City, N. J., June 27 to July 1, 1960, in connection with the 63rd Annual Meeting of the Society and the 14th Apparatus Exhibit. The important fact to keep in mind is that the time has now arrived for all interested technical photographers to make plans for submitting their best photographs for display.

Materials Processing, Testing, and Research will be the theme of the photo show. Photographs featuring apparatus, instruments, processing techniques, testing, standards, and related items are especially desired. Photographs showing unique or unusual applications of materials are welcome, also those featuring the human element.

Any ASTM member or employee of a member company or university student interested in engineering materials may submit entries in one or more of the following classes:

1. *General*
   (*a*) black-and-white or monochrome prints
   (*b*) color prints
   (*c*) color transparencies
2. *Photomicrographs*
   (*a*) black-and-white prints
   (*b*) color prints
   (*c*) color transparencies
3. *Electron micrographs*

Closing date for receipt of entries will be Saturday, May 21, 1960.

All members and committee members are being sent an application form with full details regarding rules and regulations. Extra entry forms may be obtained by writing to Society Headquarters, Attention: Photographic Exhibit.

Actions on Standards

THE ADMINISTRATIVE COMMITTEE ON STANDARDS is empowered to pass on proposed new tentatives and revisions of existing tentatives, and tentative revisions of standards offered between Annual Meetings of the Society. On the dates indicated the Standards Committee took the following actions. Anyone interested in securing copies of the standards should write to Headquarters regarding their availability.

Steel

Tentative Specification for High-Strength Structural Steel (A 440 – 59 T)

New Tentative (Accepted Nov. 11, 1959).—This specification covers high-strength steel shapes, plates, and bars of structural quality intended primarily for use in the construction of riveted or bolted bridges and buildings, and for other special structural purposes where saving in weight is important. The atmospheric corrosion resistance of this steel is approximately twice that of structural carbon steel. The specification is limited to material up to and including 4 in. in thickness.

Wrought Iron

Tentative Specifications for Welded Wrought Iron Pipe (A 72 – 56 T)

Tentative Specifications for Cold-Drawn Wrought Iron Heat-Exchanger and Condenser Tubes (A 382 – 55 T)

Revision (Accepted Nov. 6, 1959)—Numerous changes were made in Specifications A 72 and A 382 in order to bring them up to date.

Corrosion of Iron and Steel

Tentative Specification for Zinc-Coated (Galvanized) Iron or Steel Sheets, Coils, and Cut Lengths (A 93 – 58 T)

Tentative Specification for Long Terne Iron or Steel Sheets, Coils, and Cut Lengths (A 308 – 58 T)

Tentative Specification for 1.25 oz Class Coating (Pot Yield) Zinc-Coated (Galvanized) Iron or Steel Roofing Sheets (A 361 – 58 T)

Revision (Accepted Oct. 27, 1959)—The tolerance limits given in these specifications for widths of 48 and 50 in. were no longer in accordance with industry practice. Changes have been made in Table VI of Specification A 93, and in Table V of Specifications A 308 and A 361 to rectify this.

Ferro-Alloys

Standard Specifications for Ferromolybdenum (A 132 – 50)

Revision and Reversion to Tentative (Accepted Nov. 6, 1959)—In Table I, the maximum per cent of carbon for Grade A was changed from "2.5" to "2.00 to 2.50." This change was made at the request of the U. S. Government to distinguish the grades by carbon content. Grade A had been expressed only as a maximum and according to literal interpretation would have included Grade B.

Non-ferrous Metals and Alloys

Standard Specification for White Metal Bearing Alloys (Known Commercially as "Babbitt Metal") (B 23 – 49)

Revision and Reversion to Tentative (Accepted Nov. 6, 1959)—Some of the alloys covered by the specification have shown poor engineering properties and therefore have been dropped. There has been added a new alloy No. 13, corresponding to SAE alloy 13. The specification now covers 7 alloys; previously it had covered 14 alloys.

Cement

Tentative Method of Test for Compressive Strength of Hydraulic Cement Mortar (Using Portions of Prisms Broken in Flexure) (C 349 – 57 T)

Revision (Accepted Oct. 27, 1959)—Changes were made in Fig. 1, and several sections of the text were revised since either they were inadequate or were not in agreement with the revisions in Fig. 1.

Manufactured Masonry Units

Tentative Specifications for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units (C 126 – 58 T)

Revision (Accepted Nov. 6, 1959)—The revision consisted of a change in Section 5(*a*) on Imperviousness, and in Tables III and V tighter requirements have been introduced on dimensional variations for Series 6M units since it had been determined that the manufacturers of such units can easily meet the tighter requirements.

Standard Specifications for Vitrified Clay Filter Blocks for Trickling Filters (C 159 – 55)

Revision and Reversion to Tentative (Accepted Nov. 6, 1959)—Requirements have been included for a new Type I-H "high-rate" filter block, recently developed and now in production by a number of manufacturers, whose cross-sectional drainage area is twice that of the standard-rate block.

Standard Methods of Sampling and Testing Brick (C 67 – 57)

Tentative Revision (Accepted Nov. 6, 1959)—Quite often, when brick longer than 8 in. are tested in accordance with present requirements, the bearing area of half a brick will be such as to make it impossible for some testing machines to crush the specimen. In order to overcome this situation, the tentative revision provides that the test specimen shall consist of length of brick equal to its width plus or minus 1 in.

Standard Specifications for Building Brick (C 62 – 58)

Tentative Revision (Accepted Nov. 6, 1959)—This revision, in effect, adds two more weathering regions in order to provide a more precise application of the weathering index.

Standard Specifications for Facing Brick (C 216 – 57)

Tentative Revision (Accepted Nov. 6, 1959)—The specifications have been brought into agreement with the Specifications for Building Brick (C 62) in so far as the application of the weathering index is concerned.

Clay Pipe

Tentative Specification for Standard Strength Ceramic Glazed or Unglazed Clay Sewer Pipe (C 261 – 57 T)

Revision (Accepted Nov. 6, 1959)—The crushing strength requirements have been increased, making them identical with the crushing strength requirements of the Specification for Standard Strength Clay Sewer Pipe (C 13).

Tentative Specification for Extra Strength Clay Pipe (C 200 – 57 T)

Revision (Accepted Nov. 6, 1959)—Requirements for 4-in. clay pipe have been added to the specification.

Soils for Engineering Purposes

Tentative Method for Grain-Size Analysis of Soils (D 422 – 54 T)

Revision (Accepted Nov. 9, 1959)—In a footnote to Section 2(*b*), recognition is given to the air dispersion tube developed at Iowa State College; in Section 17(*c*) the word "size" is added after the words silt and clay; a Note was added to Section 1 indicating that separation of the soil sample may be made on the No. 4, No. 40, or No. 200 sieve instead of the No. 10 sieve, but the size shall be indicated in the report.

Tentative Method of Test for Liquid Limit of Soils (D 423 – 54 T)

Revision (Accepted Nov. 9, 1959)—The hand method for performing the liquid limit test of soils has been deleted.

Industrial Water

Tentative Method of Test for Odor of Industrial Waste Water (D 1292 – 53 T)

Revision (Accepted Oct. 2, 1959)—The method has been completely revised and now covers industrial water as well as industrial waste water. It calls for the reporting of odor intensity index, and threshold odor number. The method had included previously a table for the classification of odor (mandatory), whereas the revised method includes in an appendix a system for classification of odor.

Plastics

Tentative Method for Particle Size Analysis of Powdered Polymers and Copolymers of Vinyl Chloride (D 1705 – 59 T)

New Tentative (Approved Oct. 27, 1959)—This method is applicable to the particle size analysis of powdered polymers and copolymers of vinyl chloride having particle sizes larger than 44 μ (No. 325 sieve). The wet sieve technique assures elimination of static charges which cause resin particle agglomeration. A wetting agent promotes complete displacement of air in porous resins. Adjustments in sample size are recommended to prevent malfunctioning of sieves with finer resins.

Tentative Recommended Practice for the Presentation of Capillary Flow Data on Molten Thermoplastics (D 1703 – 59 T)

New Tentative (Approved Oct. 27, 1959)—There has been considerable variation in the literature in the methods used to report capillary flow data on molten thermoplastics, and as a result there is often difficulty in comparing data from various sources. This recommended practice describes a preferred manner of reporting data on molten thermoplastics obtained from a capillary rheometer. Certain possible sources of experimental error are outlined.

Standard Method of Test for Haze and Luminous Transmittance of Transparent Plastics (D 1003 – 52)

Revision and Reversion to Tentative (Approved Oct. 27, 1959)—Revisions have been made dealing with the use of the recording spectrophotometer and accounting for designation of the preferred CIE source.

Tentative Specification for Polyethylene Molding and Extrusion Materials (D 1248 – 58 T)

Revision (Accepted Nov. 6, 1959)—Several revisions have been made in Section 6 on Methods of Testing in order to keep the specification in line with current accepted practices in the industry, and to remove ambiguity. Section 11(*f*) on Environmental Cracking has been deleted, since a separate method has been published on environmental cracking.

Standard Method of Test for Ammonia in Phenol-Formaldehyde Molded Materials (D 834 – 57)

Revision and Reversion to Tentative (Accepted Nov. 6, 1959)—There has been added a rapid qualitative test for ammonia in phenolic plastics.

Atmospheric Sampling and Analysis

Tentative Method of Test for Particulate Matter in the Atmosphere (Optical Density of Filtered Deposit) (D 1704 – 59 T)

New Tentative (Accepted Oct. 27, 1959)—This method measures the extent of soiling or darkening of clean filter paper or other white fibrous media by filtration of particulate matter in the atmosphere. Measurement is based on the light transmission or reflectance properties of the deposited solid or liquid particles that originally were dispersed in a gaseous medium.

General Methods of Testing and Specifications

Tentative Specifications for Apparatus for the Microdetermination of Nitrogen by the Dumas Method (E 148 – 59 T)

New Tentative (Accepted Oct. 27, 1959) These specifications cover apparatus used for the microdetermination of nitrogen by the Dumas method, including carbon dioxide supply, gas control unit, combustion unit, and measuring apparatus.

Tentative Method of Test for Bulk Density of Abrasive Grains (E 153 – 59 T)

New Tentative (Accepted Oct. 27, 1959)—This method was developed by Committee E-1 at the request of the Abrasive Grain Assn. In this method, the bulk density of abrasive grains is determined by the weight of grain required to fill a cylinder of 100 cu cm approximate capacity when the abrasive is allowed to flow through a funnel and fall from a fixed height.

Tentative Methods of Compression Testing of Metallic Materials (E 9 – 52 T)

Revision of Tentative (Accepted Oct. 27, 1959)—The revisions clarify certain features of the compression test method. The revisions resulted in part from revised definitions included in the Definitions of Terms Relating to Methods of Mechanical Testing (E 6).

Tentative Methods of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials (E 18–57 T)

Revision (Accepted Oct. 27, 1959)—Two tables have been added giving correction values for Rockwell hardness obtained on cylindrical specimens of various diameters. They cover corrections for Rockwell B, F, and G values, and for Rockwell superficial hardness.

The Society Appoints...

Roger Sutton, The International Nickel Co., Inc., as ASTM representative on the Program Committee for the 1960 Nuclear Congress.

J. W. Stillman, E. I. du Pont de Nemours and Co., Inc. (retired), as ASTM representative at the Conference on Chemical Compounds of Certified High Purity.

M. N. Clair, The Thompson and Lichtner Co., Inc., to represent the Society at the inauguration of Asa Knowles as President of Northeastern University.

J. G. Turk, Owens-Illinois Glass Co. (chairman, Committee D-10 on Shipping Containers) to the Joint TAPPI-ASTM Coordinating Committee.

H. D. Monsch, Aluminum Company of America and **J. M. Keyes,** Wolverine Tube Division of Calumet & Hecla, Inc., as ASTM representatives on SAE Non-Ferrous Metals Technical Committee, replacing I. V. Williams and V. P. Weaver.

A. S. Jameson, International Harvester Co., as ASTM representative on the SAE Iron and Steel Technical Committee, replacing J. A. Blecki.

C. L. Clark, The Timken Roller Bearing Co., to ASA Sectional Committee B78 on Heat Exchangers for Chemical Industry Use.

J. G. Cekal, Crane Co., to ASA Sectional Committee A112 on Dimensional Standardization of Plumbing Equipment.

F. M. Clark, General Electric Co., to ASA Sectional Committee C59 on Electrical Insulating Materials.

Kenneth Wechsler, Westinghouse Electric Corp., and **H. S. Endicott,** General Electric Co., to new ASA Sectional Committee on Insulation Coordination.

Emission Spectroscopy

Tentative Recommended Practices for Photographic Processing in Spectrochemical Analysis (E 115 – 56 T)

Revision (Accepted Nov. 6, 1959)—The revisions are intended to provide for a standard form of reference, in Committee E-2 methods, to Recommended Practices E 115, and to cover more adequately certain important details of photographic processing as related to emission spectroscopy.

Tentative Recommended Practice for Photographic Photometry in Spectrochemical Analysis (E 116 – 56 T)

Revision (Accepted Nov. 6, 1959)—There has been added a new Section 2 on References to These Practices in Standards, which will promote use of a standard form of reference to Rec. Practices E 116 in methods prepared by Committee E-2. This will make unnecessary a detailed description of the emulsion calibration.

Methods of Testing Building Constructions

Tentative Methods of Testing Materials Used as Vapor Barriers Under Concrete Slabs and as Ground Cover in Crawl Spaces (E 154 – 59 T)

New Tentative (Accepted Oct. 27, 1959)—These test methods cover procedures to be used in determining the properties of flexible membranes that are related to the serviceability of vapor barriers, when such membranes are used under concrete slabs and as ground cover in crawl spaces. The methods are applicable to such materials as asphalt-treated papers and felts, plastic films, and flexible sheets.

Proposed Specification for Sealing Compounds for the Building Trade (Polysulfide Base or Equivalent)

This proposed specification represents the combined efforts of two industry groups to fill an urgent need for a material standard for a type of sealing compound that has found wide usage throughout the country, particularly in building construction. The Building Trade Specifications Committee and the Rubber and Plastics Adhesives and Sealant Manufacturers Council have jointly reviewed and approved this specification and have presented it to the American Standards Assn. for approval as American Standard under the General Acceptance Method. The newly organized ASTM Committee C-24 on Joint Sealants will give further consideration to this specification

Scope

1. This specification covers performance properties of polysulfide base sealing compounds, or equivalent, including curing agents, for use in sealing, caulking, or glazing applications in buildings. Use of a primer under certain conditions when recommended by the manufacturer is acceptable.

Description

2. Materials covered by this specification are two-package systems consisting of a polysulfide base compound, or equivalent, and an accelerator compound. The compounds are stable separately, and when properly mixed, convert to a rubber-like solid which meets the requirements herein specified. The selection of the base polymer, fillers, and other components shall be optional with the supplier, but shall be suitable for the application intended.

Specification Requirements

Classes

3. The sealing compound shall be supplied in two classes as follows:

(*a*) *Class A* (*Self-Leveling*) shall be a compound which, when properly accelerated, has sufficient flow to give a smooth, level surface when applied in a horizontal seam at ambient temperatures between 40 and 100 F.

(*b*) *Class B* (*Nonsag*) shall be a compound which, when properly mixed, permits application in vertical seams at ambient temperatures between 40 and 100 F without sagging.

Color

4. The color of the sealing compound may be any color agreed upon by the supplier and the purchaser.

Stability

5. The stability of the base compound and accelerator in original unopened containers shall be at least 6 months from the time of delivery, when stored at a temperature not exceeding 80 F. When tested at the end of 6 months after time of delivery, the compound shall meet the requirements herein specified.

Handling Properties

6. (a) Application Life:

(*1*) *Requirement.*—A properly mixed compound shall be suitable for satisfactory application for at least 4 hr when maintained at a temperature of 77 ±2 F and 50 ±5 per cent relative humidity. This test shall be performed on the two components that have been conditioned at least 16 hr at this temperature and humidity. Application life shall be considered to begin within 10 min after mixing the two components. This requirement may be changed, however, by mutual agreement between the supplier and the purchaser, when the compounds are to be used under widely varied conditions.

(*2*) *Method of Testing.*—A test to determine applicability shall be performed by hand mixing for 5 min, 8 fl oz of the two components, after each has been conditioned for a minimum of 16 hr at 77 ± 2 F, then performing trial application at the same temperature. Maximum application life shall be considered to be reached when the time required to discharge 6 fl oz of mixed compound, placed in a 250-6C Semco cartridge or equivalent, with no tip, and using a pressure of 50 psi, exceeds 1 min for class A compounds or 2 min for class B compounds.

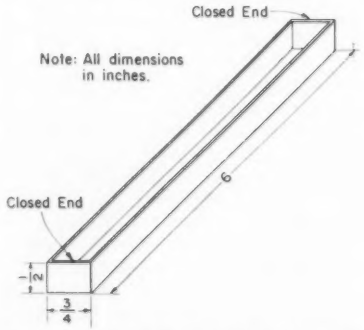


Fig. 1.—Channel for testing self-leveling compounds.

(b) Rheological Properties:

(*1*) *Test for Class A* (*Self-Leveling*) *Compounds.*—The flow of a properly prepared class A compound shall be such that the accelerated compound will self-level in a horizontal seam within 1 hr at a temperature of 40 F or higher. A test to verify this shall be performed in a test assembly using an aluminum channel with inside dimensions of ¾ in. wide by ½ in. deep by 6 in. long and closed at both ends, as shown in Fig. 1. Before preparing the test assembly, 100 g of base compound, with an appropriate amount of accelerator, unmixed, shall be conditioned at 40 ± 2 F for a minimum of 16 hr, and the aluminum channel shall also be conditioned at the same temperature for not less than 1 hr. At the end of this conditioning period the two components shall be removed from the conditioning chamber and hand mixed for 5 min. The mixed compound shall then be returned to the 40 F conditioning chamber for 30 min, after which it shall be poured into the conditioned channel, held horizontally at 40 ± 2 F, and then shall be maintained at this temperature for 1 hr. At the end of this period, the compound, upon examination, shall exhibit a smooth, level surface.

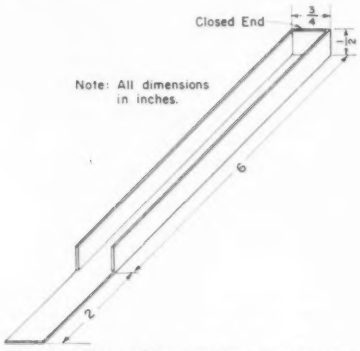


Fig. 2.—Channel for testing nonsag compounds.

(*2*) *Test for Class B* (*Nonsag*) *Compounds.*—The flow of a properly prepared class B compound shall be such that the compound will not sag more than ¼ in. in vertical displacement at

temperatures of 40 and 100 F. Two tests shall be made to verify this, using for each a channel with inside dimensions of $\frac{3}{4}$ in. wide by $\frac{1}{2}$ in. deep by 6 in. long, with the bottom surface extended 2 in. at one end, as shown in Fig. 2. Before preparing the test assemblies, 200 g of base compound, with an appropriate amount of accelerator, unmixed, shall be conditioned at 77 ± 2 F for a minimum of 16 hr, and the two channels shall be conditioned for not less than 1 hr, one at 40 ± 2 F and the other at 100 ± 2 F. At the end of this conditioning period the components shall be hand mixed for 5 min. The conditioned channels shall be removed from their respective conditioning chambers and both shall be filled by spatula with the mixed compound within 1 min. The filled channels shall then be returned to their respective conditioning chambers, placing the long dimension of the channels vertically with their open ends downward. At the end of 1 hr the channels shall be inspected, and the sag of the compound at the bottom ends of the channels shall be measured.

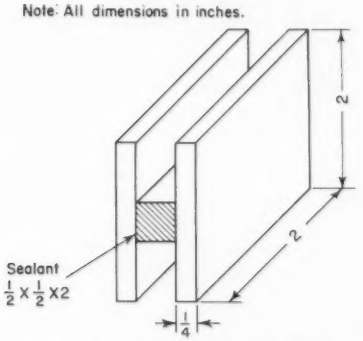


Fig. 3.—Construction of test assembly (plate glass or aluminum).

Methods of Testing

Adhesive Strength in Tension

7. (*a*) *Test Surfaces.*—Adhesion of the compound shall be tested on the following surfaces:

(*1*) Polished plate glass,

(*2*) Type 302 stainless steel (No. 4 polished finish),

(*3*) Aluminum Alloy 6063-T5, and

(*4*) portland cement concrete.

Note: Additional or fewer surfaces may be included by agreement between the sealant manufacturer and the purchaser.

(*b*) *Construction of Test Assemblies.*—Fifteen test assemblies shall be prepared using aluminum, and twelve shall be prepared using each of the other three test surfaces. These assemblies may be made by using 2 by 2 by $\frac{1}{4}$- in. plates of the test surface material, as shown in Fig. 3, in the case of plate glass or aluminum; by using 2-in. lengths of standard 2-in. T-section, as shown in Fig. 4, in the case of aluminum; by using thinner 2 by 2 by $\frac{1}{4}$-in. plates of the test surface material, if it has sufficient rigidity to withstand deformation under testing, as in the case of stainless steel; or by using relatively thin 2 by 2-in. plates of the test material securely bonded to the 2 by 2-in. faces of 2-in. lengths of aluminum T-section.

mixed compound in a $\frac{1}{2}$ by $\frac{1}{2}$ by 2-in. bead between the parallel 2 by 2-in. faces of test surfaces, as illustrated in Figs. 3 and 4. Steel spacer bars $\frac{3}{4}$ by $\frac{1}{2}$ by 2 in. long may be used to give the proper size of bead; paraffin or other nonmigrating mold release agent may be used to prevent adhesion to these spacer bars, and masking tape may be used to retain the compound and hold the assembly together. The test assemblies shall be cured for 7 days at 77 ± 2 F and 50 ± 5 per cent relative humidity before testing or further conditioning.

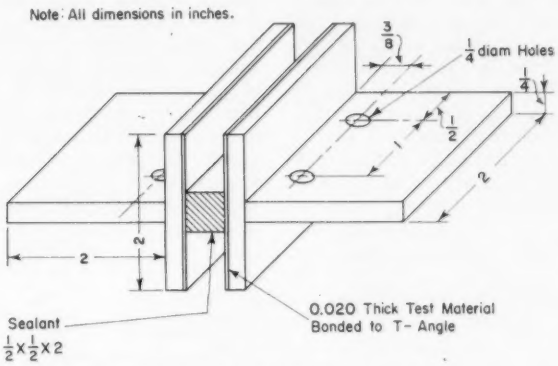


Fig. 4.—Construction of test assembly (aluminum).

Concrete test blocks shall be 1 in. thick, and shall be cast from a mixture having the following proportions: one apparent volume of portland cement (Type I or II, ASTM Specifications C 150)[1], three apparent volumes of fine aggregate (ASTM Specifications C 33),[1] and sufficient water for a $2\frac{1}{2}$ ± $\frac{1}{2}$-in. slump (ASTM Method C 143).[1]

Before constructing the test assemblies, test surfaces shall be cleaned and prepared as follows:

(*1*) *Plate Glass.*—Wash first with warm tap water, then with methylethylketone (MEK) solvent, and wipe dry with clean cotton cheesecloth.

(*2*) *Stainless Steel.*—Wash with methylethylketone solvent, then wipe dry with clean cotton cheesecloth.

(*3*) *Aluminum.*—Wash with methylethylketone solvent and wipe dry with clean cotton cheesecloth. Then immerse for 10 min in an alkaline bath containing 10 oz of Oakite No. 164[2] per gallon of water. The bath shall be maintained at 190 ± 10 F, and shall be agitated during the immersion period. Follow by rinsing in warm tap water, then in methylethylketone, and wipe dry with clean cotton cheesecloth.

(*4*) *Concrete.*—Brush test surfaces with a natural bristle brush. Prime the surface, when so required by the sealant manufacturer's directions.

(*5*) *Other Materials.*—Clean and prepare as required by the sealant manufacturer's directions.

Test specimens shall be prepared by applying 8 oz of properly conditioned

The specimens shall be scribed with a sharp knife or marking pencil along the lines where the sealant is in contact with the test surface, in order to record the original bonded area.

(*C*) *Testing Machine.*—When a tensile tester is used, the assembly shall be positioned in a set of jaws as illustrated in Fig. 5, these jaws in turn being held

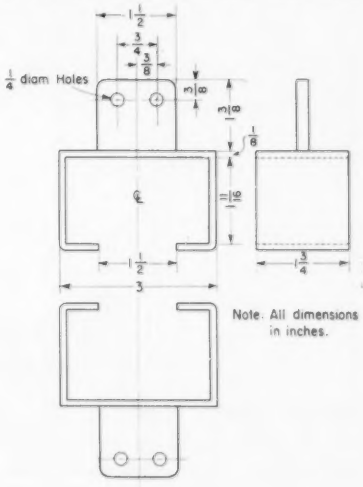


Fig. 5.—Testing jaws.

in the jaws of the tensile tester. The alternate test assembly, illustrated in Fig. 4, can be gripped directly by the jaws of the tensile tester, or it can be placed between the cutout parallel plates shown in Fig. 6, the T-sections

[1] 1958 Book of ASTM Standards, Part 4. All ASTM Standards shall be the latest available edition.

[2] Made by Oakite Products, Inc., 46 Rector St., New York 6, N. Y.

being so placed that the test bead can be held under stress by properly adjusting the separating nuts. This assembly may also be used for the low-temperature extensibility test by positioning the assemblies in the jig and periodically turning the separating nuts to separate the assembly at the desired rate.

(*d*) *Procedure.*—Three test assemblies for each of the test surfaces shall be subjected to strain immediately after the 7-day cure period by placing each test assembly in the jaws of a tensile tester and pulling it apart at the rate of 0.20 to 0.25 in. per min. The compound shall be capable of being extended 150 per cent of its original width without failure,[3] and the force required to obtain this extension shall be not less than 10 psi. The assembly shall be taken from the tensile tester and put into an assembly where it is held at the 150 per cent extension for 24 hr at a temperature of 77 ± 2 F without failure.

Note: All dimensions in inches.

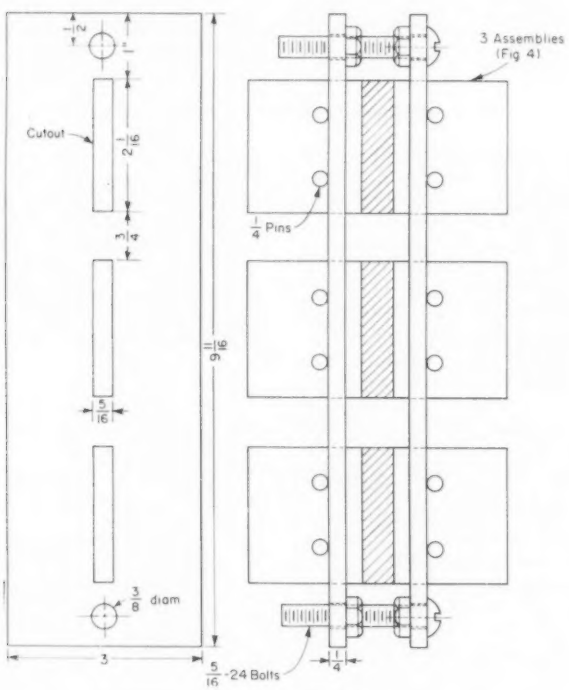


Fig. 6.—Testing jig.

Water Resistance Tests

8. Three test assemblies for each of the test surfaces shall be immersed in 900 ml of distilled water per assembly for four days at 77 ± 2 F and shall then be immediately subjected to strain by placing each in the jaws of a tensile tester and pulling it apart at the rate of 0.20 to 0.25 in. per min. The compound shall be capable of being extended 150 per cent without failure,[3] and the force required to obtain this extension shall be no less than 10 psi. The assembly shall be taken from the tensile tester and put into an assembly where it is held at the 150 per cent extension for 24 hr without failure.[3] Test temperature shall be 77 ± 2 F.

Heat Aging Tests

9. Three test assemblies for each of the test surfaces shall be heat-aged for 96 hr in a circulating hot-air oven at 158 ± 2 F and shall then be conditioned for not less than 4 hr at 77 ± 2 F. They shall then be tested for adhesion in tension by placing each assembly in the jaws of a tensile tester and pulling it apart at the rate of 0.20 to 0.25 in. per min. The compound shall be capable of being extended 100 per cent without failure (see section 12). Each assembly shall then be taken from the tensile tester and maintained at 100 per cent extension for 24 hr at a temperature of 77 ± 2 F without failure.[3]

Low-Temperature Tests

10. Three test assemblies for each of the test surfaces shall be placed in a suitable device for separating the parallel test surfaces at $\frac{1}{32}$-in increments. These devices and the contained test assemblies shall then be placed in a cold box maintained at −20 ± 2 F for not less than 4 hr. After this conditioning period, the test assemblies, still at −20 ± 2 F, shall be stretched at the rate of $\frac{1}{32}$ in. every three min, until the compound has been extended 100 per cent, and the assemblies shall be maintained at this extension, at a temperature of −20 ± 2 F for another 16 hr. The assemblies shall then be removed from the cold box. The spacers shall be removed and the assembly allowed to stand, with all tensile stress removed, at 77 ± 2 F for 4 hr. At the end of this time they shall be compressed at the rate of $\frac{1}{4}$ in. per min until they regain their original thickness, and shall then be allowed to relax for an additional 16 hr at 77 ± 2 F, thus completing one test cycle Each test assembly shall be subjected to a total of three such test cycles without evidence of failure.[3]

Recovery Tests

11. The three remaining test assemblies on aluminum surface shall be placed in an oven at 120 F for 3 days, then removed and conditioned for not less than 16 hr at 77 ± 2 F After conditioning, they shall be placed in the jaws of a tensile tester and pulled apart at the rate of 0.20 to 0.25 in. per min until extended 150 per cent. The assemblies shall be held in the tester at this extension for 5 min, then they shall be immediately removed and allowed to recover without compression by placing them edgewise on a glass surface with the long axis of the compound bead perpendicular to this surface. The compound shall recover not less than 25 per cent within 1 hr, at a temperature of 77 ± 2 F.

Recovery shall be calculated as follows:

$$\text{Recovery, per cent} = \frac{\text{Width extended} - \text{Width after recovery}}{\text{Width extended} - \text{Width initially}} \times 100$$

Evaluation of Tests

12. In each of the tests described in Sections 7 to 11, and 13(*b*) at least 2 out the 3 test specimens shall meet the specified requirements. Failure shall be considered to occur when there is either cohesive or adhesive separation exceeding $\frac{1}{10}$ in. in depth, measured with a 16-gage (0.0625-in.) wire probe held perpendicular to the face of the sealant on which separation occurs, except that failure attributable to bubbles or other specimen defects shall be discounted. If more than one specimen fails to pass requirements because of air bubbles or other application defects, another complete set of 5 specimens shall be prepared and tested; at least 3 of these shall meet the specified requirements. Only one such retest shall be permitted.

Accelerated Aging

13.(*a*) *Sunlamp Exposure for Surface Craze.*—A test panel of aluminum (sur-

[3] Fine emery cloth No. 112B obtainable from the Clover Mfg. Co., Norwalk, Conn.

face-treated, if desired, to permit easy stripping) with a 4-in.-square level patch of cured compound, $\frac{1}{8}$ in. thick, shall be exposed to a General Electric RS Sunlamp (275 w, 125 v, 50 to 60 cycle), the specimen being held perpendicular to the light rays at a distance of 12 in. from the lamp. The sunlamp strength during the test shall be between 15 and 30 E-vitons per sq cm, when tested with a General Electric RS Sunlamp Tester at a distance of 12 in. from the lamp. The air temperature at the surface of the test specimen shall not exceed 150 F during the exposure period. Exposure shall be for 96 hr, and the maximum allowable depth of crazing or surface cracking after exposure shall be 3 mils. The depth of crazing may be determined by slighty elongating the specimen and hand buffing the surface with abrasive cloth[3] until all surface imperfections are buffed off. Thickness measurements before and after buffing will determine the depth of crazing.

(*b*) *Sunlamp Exposure Through Glass.*—Three test assemblies shall be prepared, each consisting of a $\frac{1}{2}$ by $\frac{1}{2}$ by 2-in. bead of properly prepared compound between a 2 by 2-in. plate of aluminum on one side and a plate of water-white glass of the same dimensions on the other, as shown in Fig. 3. These assemblies shall be allowed to cure for 7 days at 77 ± 2 F and 50 ± 5 per cent relative humidity. At the end of this curing period the glass side of each assembly shall be exposed to ultraviolet radiation from a General Electric RS Sunlamp of the same type and strength as specified in Paragraph (*a*). Air temperature at the surface of the test specimen shall not exceed 150 F during the exposure period. Exposure shall be for 96 hr, at a distance of 12 in. from the surface of the bulb and normal to the axis through the center of the light, with at least one corner of the panel on this axis. At the end of the exposure period the test assemblies shall be immersed in 900 ml of distilled water per assembly for 4 days at 77 ± 2 F and then immediately subjected to strain by placing each in the jaws of a tensile tester and pulling it apart at the rate of 0.20 to 0.25 in. per min. The compound shall be capable of being extended 100 per cent without failure (See Section 12), and the force required to obtain this extension shall be not less than 10 psi.

Staining of Masonry

14. This test shall be required only when the compound is to be used in contact with marble, limestone, or decorative concrete. The test shall consist of preparing a test slab of mortar mix, upon which is placed the properly mixed sealant compound. The mortar mix shall consist of one part by volume of white or gray portland cement, one half part by volume of unslaked lime, three parts by volume of standard Ottawa sand (20 to 30 mesh) and sufficient water to form a smooth paste. The mortar shall be spread upon a smooth glass surface so that it roughly forms the shape of a doughnut 3 in. in diameter and $\frac{1}{2}$ in. thick, with a $\frac{3}{8}$-in. diameter hole. The mortar shall be allowed to set for from 1 to 4 hr at 77 ± 2 F. Then 24 g of freshly mixed sealant compound shall be applied over the center hole of the mortar, in a thickness of $\frac{1}{4}$ to $\frac{1}{2}$ in. The assembly shall be allowed to condition for 24 hr at 77 ± 2 F and 50 ± 5 per cent relative humidity. Once a day thereafter, for a total of 14 days, the specimen shall be completely immersed for 1 min in distilled water, and then shall be examined for any evidence of discoloration in the mortar. The first appearance of any discoloration shall be construed as staining. If no such discoloration appears within 14 days, the compound shall be considered to be nonstaining.

This is one of a series of photographs from a collection compiled by Prof. Jasper O. Draffin and displayed in the Arthur N. Talbot Laboratory, University of Illinois.

OCTAVE CHANUTE (1832–1910). Born in France, Octave Chanute came to America at the age of six. His life was devoted primarily to railroad and bridge work. He made excellent contributions to studies of railroad rails and the preservation of timber. A pioneer in research on heavier-than-air flying machines, he was a confidant of the Wright Brothers. Chanute Air Force Base, in Illinois, is named in his honor.

"The Messrs. Wright are now gliding very nearly as well as the vulture, which generally descends one meter in ten (5°45′) in calm air. It is therefore not impossible that man shall eventually master sailing flight and learn . . . to imitate the soaring birds which circle and rise through the force of the wind alone."

L'Aerophile, August, 1903

MATERIAL QUESTIONS

(*Continued from page 25*)

changes in atmospheric humidity and temperature. Such changes can exert rather severe and repeated stresses on glue lines, particularly from season to season. These stresses are particularly severe in higher density species, thicker members, and crossed-grain constructions. They are believed to be often more severe than the stresses resulting from external loads applied in service. There is a considerable body of data which show that glued wood products will not successfully withstand long periods of moisture content cycling, or outdoor weathering, even when glued with the most durable resin glues, without delaminating, unless glued under conditions capable of producing not only high strengths in initial control tests, but also high percentages of wood failure.

Differences of 100 or 150 psi in shear strength in a conventional shear test, such as you cite, with low percentages of wood failure in each case, are not generally of much real significance. But differences between joints of 350 psi with 0 per cent wood failure and 350 psi with 90 to 100 per cent wood failure are quite significant and indicate a marked superiority of the latter joint over the former.

The knife test is a short cut to wood failure estimation. Even if a relationship could be developed with the mechanical test, it is doubtful if the results could be used as you imply. Here again, the primary criterion of joint quality would be the amount of wood failure in the broken joint.

Are You Galled by Wear?

Companies are frequently asked for the relative ability of different materials to resist galling and wear in rubbing contact. There appears to be no existing standardized procedure for carrying out such tests. This is a very difficult problem in that any standardized procedure would probably need to be based on a number of arbitrary features.

As a result of mounting interest in this problem, ASTM plans to call a small conference of industry representatives on wear and gall tests. The conference will discuss the present state of test procedures for evaluating resistance to wear and galling, and for determining coefficient of friction. Any company or person interested in participating in this activity should get in touch with ASTM Headquarters.

In 1937, ASTM sponsored a Symposium on Wear of Metals and, in 1952, one on Fretting Corrosion. Except for several papers that have been published throughout the years in the ASTM *Proceedings*, these represent the only publications by ASTM in this field.

Emperor Caligula Insisted on Quality Valves

Courtesy Chemical Engineering

ANCIENT ROMANS built their pipes, valves and fittings according to modern ASA and ASTM standards! This is the conclusion reached by Mario Fera (above, right), senior engineer for the Italian engineering firm, Compagnia Tecnica Industrie Petroli, S.P.A., of Rome, exhibiting in New York at the Fifth World Petroleum Congress in June.

According to Dr. Fera, an 80-lb valve (replica shown above) salvaged from one of Emperor Caligula's yachts is made of a zinc-free, lead-rich, anticorrosion, antifriction tin bronze. This metal has a composition very similar to ASTM B 144-3D cast acid metal and ASTM B 144-3E antifriction bronze. The Caligula valve was found submerged at the bottom of Lake Nemi in Rome. Although 19 centuries old, it still exhibits highly polished surfaces and retains its plug tightly.

Other valves found in and about Rome and Naples are equally well preserved, Dr. Fera said. One found at a reservoir in a Roman villa was used regularly until three years ago by the peasants whenever they required water for irrigation. In 1956, it was decided that the cost of the valve had been amortized, and it was replaced after 20 centuries of service.

Reprinted from

Chemical Engineering, July 27, 1959.

Segregation in Aluminum–13 Per Cent Uranium Castings[1]

By D. PECKNER

The possible existence of long-range uranium segregation in aluminum-13 per cent uranium castings was investigated. Chemical analysis indicated that castings were relatively homogeneous on a macroscopic scale. An anomalous phase, UAl_3, was observed in the castings which can be accounted for on the basis of solidification theory.

An alloy of aluminum–13 per cent uranium has been proposed for use as a fuel element material. The proposed fuel element is cast in the form of a hollow cylinder by pouring into a preheated graphite mold cored with a graphite rod. After final machining the cylinder is clad with aluminum on both the inner and outer diameters by coextrusion. Homogeneity is an important requirement for the prevention of hot spots caused by areas of high uranium concentration which could conceivably damage the fuel element cladding, with subsequent release of radioactive products into the reactor cooling system. The purpose of this study was to investigate the alloy for possible long-range segregation of uranium and to observe metallographically the microstructure of several castings.

To prepare the alloy, aluminum is melted and superheated to 925 C in a high-frequency induction furnace operated at 3500 cps. Uranium shot is then added to the melt. The high-density uranium shot drops to the bottom of the crucible, and, to promote homogeneity, the alloy is electromagnetically stirred in the high frequency field for 15 min.

Investigation of Chemical Segregation

Wall sections of two castings in which severe segregation was suspected were made available for examination. In order to determine whether long-range, or macroscopic, chemical segregation had occurred, the sections were submitted to an extensive series of X-ray spectrographic analyses (also known as fluorescent analysis). A total of 66 areas $\frac{1}{8}$ in. in diameter were examined in this manner.

The principle of fluorescent X-ray analysis has been described previously (1).[2] A beam of heterogeneous X-rays from an excitation tube strikes the sample, causing it to fluoresce the characteristic X-ray spectra of the elements present. This secondary radiation is diffracted and separated into individual wavelengths by a single crystal monochromator. The intensity of the diffracted X-rays, which is proportional to the amount of elements present, is measured by a Geiger counter in conjunction with standard electronic scaling units.

Six of the areas examined by fluorescent analysis were drilled out and colorimetrically analyzed for uranium

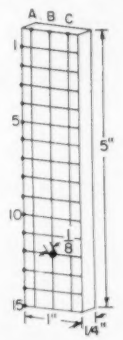


Fig. 1.—Grid used to code sample points. Sample area indicated is B12. Same identification used for casting 285 and 287.

content by Cheng's method (2), which has an estimated accuracy of ± 0.3 per cent of uranium present, in order to provide a means for converting raw X-ray spectrographic data to chemical percentages. A correlation between the colorimetric data and the X-ray spectrographic data was obtained by the least squares method. Samples in the immediate vicinity of areas drilled for colorimetric analysis were examined metallographically. In addition, all samples were examined by X-ray diffraction techniques to determine the phases present in the matrix.

Figure 1 indicates the manner in which test points were coded. The sample in each case was a section through the casting wall approximately 1 in. wide and 5 in. long. Casting 285 was thoroughly analyzed, with analyses made at each $\frac{1}{2}$ in. across the width and along the length. Casting 287 was spot checked because of the apparent uniformity of analyses made on casting 285. Tables I and II present the results of the colorimetric and fluorescent analyses and indicate that the two sections examined were relatively homogenous. Casting 285 had an average uranium content of 13.3 per cent with a variation of ±0.5 per cent; casting 287 had an average uranium content of 13.8 per cent with a variation of ± 0.5 per cent. This variation can be expected in any casting and actually indicates excellent homogeneity in the two castings examined.

Microstructure and Solidification of the Aluminum-13 Per Cent Uranium Alloy

The equilibrium diagram of the aluminum-uranium system (Fig. 2) indicates that the eutectic occurs at 13 per cent by weight uranium and predicts that only primary aluminum and the intermetallic compound UAl_4 should be observed in this composition area. However, X-ray diffraction data indicate that the following phases are present in all areas of both castings: primary aluminum and the intermetallic compounds UAl_3 and UAl_4. From the phase diagram, the phase found by metallographic examination and identified by X-ray diffraction techniques as UAl_3 should not occur under normal solidification.

D. PECKNER was a metallurgical engineer, Materials Engineering Department, Westinghouse Electric Corp. when this paper was prepared. In this capacity, he was responsible for application work in both ferrous and nonferrous metals. His specialties included applications of sheet metals, permanent mold casting, tool steels, stainless steels, and effects of radiation on metallic materials. He received a B.S. in Metallurgical Engineering from the Polytechnic Institute of Brooklyn in 1949 and is currently taking graduate work at the University of Pittsburgh. He is now an Associate Editor of the magazine *Materials in Design Engineering*.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Presented at the fifth Nuclear Congress, Cleveland, Ohio, April 5–10, 1959.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

TABLE I.—COMPARISON OF COLORIMETRIC AND X-RAY FLUORESCENT ANALYSES.

Sample	Area	Colorimetric Analysis, per cent of Uranium	X-Ray Fluorescent Analysis, per cent of Uranium
285....	A 1	13.3	12.8
285....	A 8	13.6	13.5
285....	C 14	13.2	13.8
287....	A 11	13.2	13.9
287....	B 3	14.2	14.2
287....	B 15	13.1	13.3

TABLE II.—DETAILED X-RAY FLUORESCENT ANALYSIS OF CASTINGS.

Casting 285, per cent of Uranium				Casting 287, per cent of Uranium			
	A	B	C		A	B	C
1.....	12.8	13.0	12.9	1.....	...	13.0	13.5
2.....	13.0	12.7	12.7	2.....	13.9	14.1	14.2
3.....	13.4	12.9	13.3	3.....	14.0	14.2	13.8
4.....	13.5	13.0	13.1	4.....	14.0	14.2	14.3
5.....	13.4	12.9	13.1	5.....	...	...	...
6.....	13.3	13.2	13.2	6.....	13.0	...	...
7.....	13.3	13.0	13.4	7.....	13.9	...	...
8.....	13.5	13.4	13.4	8.....	14.0	...	...
9.....	13.3	13.0	13.3	9.....	...	13.7	...
10.....	13.6	13.5	13.4	10.....	...	14.1	...
11.....	13.4	13.1	13.0	11.....	13.9	...	14.1
12.....	13.6	13.1	13.5	12.....	...	...	...
13.....	12.7	13.3	12.9	13.....	...	13.6	...
14.....	13.7	13.8	13.8	14.....	...	13.5	...
				15.....	...	13.3	...
Average 13.3%				Average 13.8%			

It is apparent from a study of the microstructure that primary aluminum forms a continuous phase in the solidifying matrix. This is seen in Fig. 3(*a*) to (*e*) and indicates that aluminum is nucleating before either UAl_3 or UAl_4. The photomicrographs are presented in sequence, with Fig. 3(*a*) representing the top of the casting and Fig. 3(*e*) the bottom. The intermetallic compounds UAl_3 and UAl_4 are present in all photomicrographs, the UAl_3 appearing as discrete particles and the UAl_4 as the lamellar constituent. The amount of UAl_3 present decreases from the bottom of the casting to the top since, for reasons discussed below, the amount of UAl_3 present should decrease as the casting cooling rate decreases.

The reason for the preferred nucleation of aluminum may, perhaps, be related to the crystal lattice structures of aluminum, UAl_3, and UAl_4. These are as follows:

Phase	Lattice Type
Aluminum	Face-centered cubic
UAl_3	Simple cubic
UAl_4	Orthorhombic

Both aluminum and UAl_3 will probably nucleate before UAl_4 because of their simpler lattice structure. One would expect that aluminum would be most likely to nucleate since all atoms in the lattice are of the same type. UAl_3, because of its lattice type, may nucleate either in the melt or on the aluminum substrate whereas UAl_4 probably cannot nucleate on the aluminum substrate and must, therefore, nucleate in the melt.

While the equilibrium diagram does not predict this type of phase, one must remember an equilibrium diagram alone cannot predict the actual mode of solidification. The diagram can be used, however, in combination with metallographic examination, to explain the actual mode of solidification with a certain probability.

Considering the equilibrium diagram (Fig. 2) once again, if the prolongation of the aluminum liquidus line is followed to point A, it can be seen that the degree of supercooling with respect to UAl_3 (ΔT_1) is much greater than with respect to UAl_4 (ΔT_2). The UAl_4 is supercooled only 15 to 20 C while UAl_3 is supercooled almost 110 C. Therefore, one may expect that in this case the UAl_3 will be most favored for nucleation.

As the aluminum crystallites advance into the melt, Tiller (**3, 4**) and Chalmers (**5**) predict that the alloy will become constitutionally supercooled through redistribution of the solute in the melt. The primary aluminum crystallites, on freezing, enrich the melt in uranium. The aluminum-liquid interface region is therefore one of rather higher uranium content than the melt average. As the aluminum dendrites grow and impinge on each other, the areas between the dendrites will exhibit an increase in solute concentration. When the concentration is raised to point A on Fig. 2, both UAl_3 and UAl_4 will nucleate, the nucleation frequency being different for the two phases.

Nucleation of UAl_3 either in the interdendritic liquid or on the aluminum substrate will decrease the concentration of uranium in the melt at the point of nucleation and raise the temperature because of release of the latent heat of fusion of UAl_3. UAl_4 may then begin to nucleate. It should be noted that while UAl_3 is forming at one point in the melt, another point may be following the equilibrium diagram more closely so that at the eutectic temperature, the eutectic structure is appearing. Therefore, the photomicrographs shown in Fig. 3(*a*) to (*e*) are not unreasonable as representing the normal structure of the solidified alloy. Any one of these photomicrographs taken by itself is not representative of the structure of the casting. Chalmers (**5**) has pointed out that this type of phenomenon frequently occurs in cast structures.

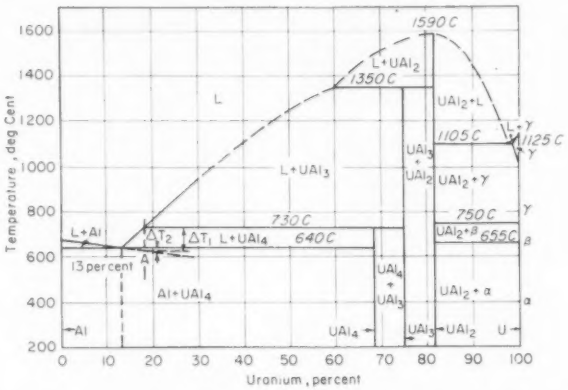


Fig. 2.—Equilibrium diagram of the aluminum–uranium system.

There has been some concern that uranium is segregating in the melt, thus giving rise to the high uranium content necessary for the nucleation of UAl_3 according to the equilibrium diagram. The equilibrium diagram of the aluminum-uranium system indicates that uranium is completely soluble in aluminum above the liquidus so that segregation of this type cannot be expected if homogenization of the melt has first occurred. The chemical analyses shown in Tables I and II are a further indication that gross segregation of uranium in the melt does not occur under normal freezing conditions.

Conclusions

1. No chemical evidence of long-

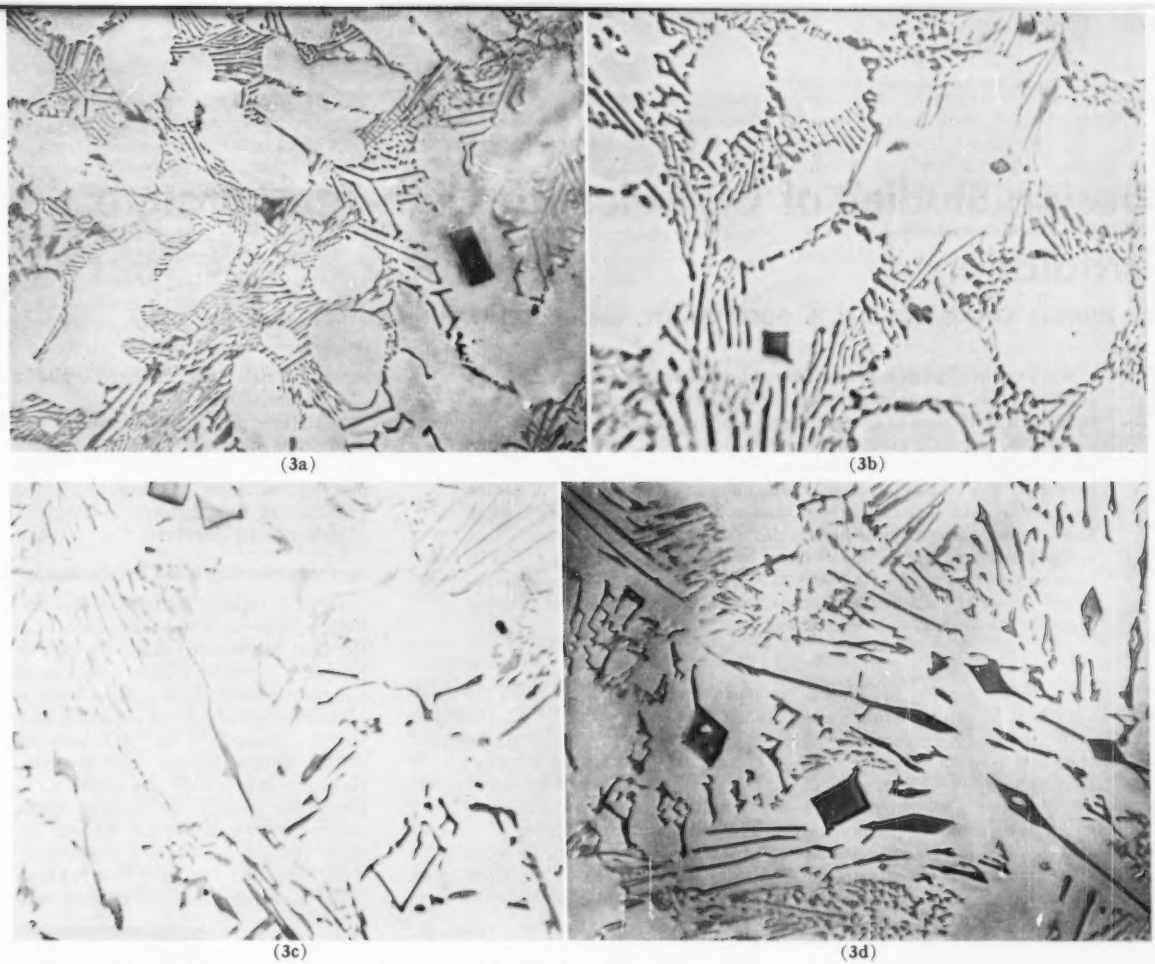


Fig. 3.—Sections of casting 285 taken in sequence (× 500).
(*a*) represents the top of the casting.
(*b*, *c*, and *d*) continuous phases present are primary aluminum (white), a eutectic of Al and UAl_4 (lamellar), and UAl_3 (discrete particles).
(*e*) represents the bottom of the casting.

range chemical segregation was found in castings of an aluminum–13 per cent uranium alloy.

2. The phases present in aluminum–13 per cent uranium castings are primary aluminum and the intermetallic compounds UAl_3 and UAl_4

3. The presence of UAl_3 in the matrix can be explained by a consideration of normal dynamic solidification processes.

Acknowledgments:

The author wishes to thank Dr. W. A. Tiller for several discussions concerning solidification theory. We would also like to thank Mrs. D. Rahn for permission to include as Fig. 3(*a*) to (*e*) photomicrographs which originally appeared in Westinghouse Atomic Power Department Metallurgical Report 26.

References

(1) W. Parrish, "X-Ray Spectrochemical Analysis," *Norelco Reporter*, Vol. 3, No. 2–5, p. 24 (1956).

(2) K. L. Cheng and P. F. Lott, "Reaction of Hydrogen Peroxide with Complexes of (Ethylenedinitrilo) Tetraacetic Acid and Nitrilotriacetic Acid," *Analytical Chemistry*, Vol. 28, p. 462 (1956).

(3) W. A. Tiller, K. A. Jackson, J. W. Rutter, and B. Chalmers, "The Redistribution of Solute Atoms During the Solidification of Metals," *Acta Metallurgica*, Vol. 1, p. 428 (1953).

(4) W. A. Tiller and J. W. Rutter, "The Effect of Growth Conditions upon the Solidification of a Binary Alloy," *Canadian Journal of Physics*, Vol. 34, p. 96 (1956).

(5) B. Chalmers, "Melting and Freezing," *Journal of Metals*, Vol. 6, No. 5, p. 519 (1954).

Design Studies of Capsules for High-Temperature Irradiations[*,1]

By JOHN H. STANG, WILLIAM H. GOLDTHWAITE, and BRUCE W. DUNNINGTON

Since the irradiation damage suffered by fuel specimens is sensitive to small changes in temperature and burnup, improvements in precision in irradiation testing are of great importance in fuel studies.

For this reason, a preliminary engineering analysis was made of the problems of control and measurements of specimen temperature and heat generation in a NaK-filled capsule containing a fuel specimen. A specific problem is used in this report to demonstrate the large uncertainties normally encountered even in capsules containing thermocouples. This analysis indicates that an improvement by a factor of more than 3 (that is, from an uncertainty of ±70 F to ±20 F in the example used) may be obtained by use of a differential-thermocouple heat-flow meter and by use of precision thermocouple placement clips.

IRRADIATION of nuclear fuel materials at high temperatures and to high burnups requires precise control of experimental conditions under difficult circumstances (1).[2] The ambient temperature of most of the reactor space available for irradiation of experimental specimens is low compared with that desired for most experiments. The experimental materials must therefore be encapsulated and a heat barrier provided between the specimen and the ambient reactor surroundings. Widely diversified experience at Battelle over the past several years has served as the background for capsule designs that are believed to offer improved precision in testing. These capsules are primarily for irradiations in pool- or tank-type test reactors.

Specialized design problems are encountered in the usual case of fueled specimens that are desired to be irradiated at a preassigned elevated temperature in a neutron-flux field which is not accurately known and in a capsule whose heat-transfer properties are not accurately known. If internal instrumentation is not used, then the potentially large error of prediction cannot be corrected. Therefore, an instrumented capsule is required for precise experimentation.

The design of a capsule for precise testing must provide means to measure the specimen heat-generation rate and means to measure and control the specimen temperature (1, 2). Measurement of the rate of heat generation is required to calculate the rate of burnup and to calculate the temperature at points where thermocouples cannot be placed. The temperature is measured as close to the specimen as possible because the errors in extrapolation are thereby reduced, but in many practical cases these errors are still large compared with the desired precision.

With these principles in mind, a design study was made to define the major regions of uncertainty and to devise practical schemes for improving the precision of measurement and control of specimen temperature.

Factors Affecting Heat Production

When a capsule containing fuel material specimens is irradiated in a reactor, heat is generated inside the capsule primarily by fission recoils, with a small additional amount from gamma heating. Measurements of gamma ray heating are almost a necessity since the calculation of this heating effect is quite involved. However, it is usually not necessary to repeat the gamma ray heating experiments for various capsule designs because the gamma heating is generally small compared with the fission heating.

On the other hand, the thermal neu-

J. H. STANG is an assistant chief in the Engineering Mechanics Division at Battelle Memorial Institute. Mr. Stang holds an M.S. in mechanical engineering from The Ohio State University, and he has been a Battelle staff member since 1945. For the past 9 years he has been interested in a variety of reactor-engineering developments. At present he is directly responsible for the design, construction, and operation of capsules for irradiation experiments that are conducted by Battelle at the MTR, ETR and Battelle Research Reactor.

W. H. GOLDTHWAITE is chief of the Engineering Mechanics Division of the Physics Department, at Battelle, having joined the Battelle staff in 1951 after receiving an M.S. in physics from the University of New Hampshire. His research projects have included the development of a circulating supercritical water loop for heat transfer and dynamic corrosion studies and a new method of nondestructively testing cladding bonds on STR-type fuel elements. At present, he is directing research programs on bearing, valves and seals, and supervises the design and operation of in-pile capsules and loops. In addition, he is coordinating reactor fuel development and radiation effect programs for two gas-cooled reactor projects.

BRUCE W. DUNNINGTON has been active in atomic energy work for the past 8 yr, since receiving his doctor's degree in Metallurgical Engineering from The Ohio State University. He joined the du Pont Company in 1951. For several years he provided liaison between du Pont and major USAEC sites and Chalk River on the development of fuel manufacturing processes and facilities. In 1957 he joined the staff at Battelle Memorial Institute as a consultant. He has been active in the development of irradiation studies.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Fifth Nuclear Congress, Cleveland, Ohio, April 5–10, 1959.

[1] Work performed under AEC Contract W-7405-eng-92 and reported in AEC Report BMI-1292.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

tron flux in the specimen will generally change if the capsule design is altered. Although experiments can be performed to measure these flux changes, it would obviously be preferable if a simple calculational method could be used to estimate the effect of a given capsule design and fuel specimen upon the thermal neutron flux. A semiempirical method developed by Lewis is widely used at the Materials Testing Reactor (MTR) (3). Errors in estimating the flux-depression factor in some cases may be as high as ±20 per cent.[3]

Another factor to be considered in the design of an irradiation capsule is the variation of the flux during the irradiation period. These variations result from the changes in the reactor and capsule systems during this period. For example, control rod positions will vary, the fuel distribution will change, and the other reactor experiments will have a variable effect. The variations due to these causes may be as large as +100 or −50 per cent, particularly if powerful absorbers are inserted in or withdrawn from neighboring positions. In the best cases, when all due care is taken in planning the experiment and no unexpected outside interferences occur, the estimated 2-σ limit for the uncertainty in the effective flux is about ±20 per cent. For this reason alone, it is desirable to have a source of heat in the capsule which can be varied independently of the reactor operation. This then allows the total capsule heating to be adjusted to a rate necessary to maintain the desired specimen temperature regardless of the uncontrollable variations which occur.

The errors in estimating the fission heating can be compensated by the externally controlled heat. However, it is still necessary to keep the estimate of the fission heat fairly accurate to obtain an efficient capsule design. If the error in the estimate is too large, it will not be possible to insert a large enough electrical heater to cover the possible variations.

Factors Affecting Heat Transfer

With auxiliary heat available, the amount of total heat that is dissipated to the final sink is controllable. The design of the capsule must be such that the total heat dissipation required to achieve the desired temperature must (1) exceed the maximum nuclear heat (combined fission and gamma heat), thus precluding the possibility of having the specimen too hot with the auxiliary heater turned off; (2) be less than the sum of the minimum nuclear heat and the maximum auxiliary heat, thus precluding the possibility of having the specimen too cold with the auxiliary heater in full use.

Capsule Size

Design of irradiation capsules would be simplified if there were no restrictions on the radial dimensions of the capsule. This would make it possible to control resistance to heat flow from the fuel specimen outward merely by making suitable changes in the length of the heat-flow path. However, capsule size must fit reactor test-cell dimensions, which are generally small, particularly in high-flux regions. Other considerations which lead to a size limitation include poison effects, reactivity depression effects stemming from absence of moderator, restricted flow of cooling water, and high cost of reactor space. In the Battelle Research Reactor the test cells within the core are spaces created by the removal of 3 by 3 in. fuel element subassemblies. The recommended maximum capsule diameter at the site is about $2\frac{1}{4}$ in. In the popular A-piece (in the beryllium moderator) facilities at the Materials Testing Reactor, $1\frac{1}{8}$ in. outside diameter capsules are preferred. The highest flux positions for capsules in the Engineering Test Reactor require a 1-in. outside diameter limit.

The upper limit in capsule size dictated by the factors mentioned above, along with a lower size limit governed by fabrication and heat-removal considerations, leaves little leeway to utilize size as a design parameter.

Heat-Flow Barriers

The restricted capsule diameter makes it necessary to select various heat-flow barriers to create a large controlled gradient between the specimens and the outer capsule surface. A double-walled capsule configuration offers considerable flexibility in this selection, inasmuch as a variety of resistances to heat flow can be located in the annular space between the inner crucible and the outer shell. The wide range of heat-dissipation rates obtainable by this means, using the same basic capsule design (the same as that used later for a reference design), is illustrated by Fig. 1. The heat-flow rate values were derived from expressions for two-dimensional heat flow, since the small axial heat losses expected from such a capsule do not influence the comparisons.

For the case of low heat-flow rates, control schemes may be based on (1) regulation of thermal radiation between the walls which form the annular space, and (2) control of conduction by the gas present in the space. If temperature levels are fixed, the amount of heat transferred by radiation depends on the emissivity factor in the radiation equation.[4] If stainless steel walls are present, the effective emissivity will be approximately 0.5. This can be changed if desired simply by using other materials. For example, aluminum, which has an emissivity of about 0.15, may be used as the cold wall to reduce the effective emissivity to 0.12. If mechanical considerations make it inconvenient to use aluminum as the container material, a snug-fitting aluminum sleeve can be inserted within an outer shell of another material such as stainless steel. Radiant heat transfer can also be altered by use of radiation baffles in the annular space.

Variation of heat flow by control of the conduction between the annulus walls is an important consideration. If the space is evacuated, the conduction heat is reduced to nearly zero. However, a better way of achieving a low rate of heat flow is through the use of argon, a gas of low thermal conductivity, in the annulus. Considerably higher conduction rates may be obtained with helium, since it has roughly ten times the thermal conductivity of argon. Argon-helium mixtures can provide particularly fine control, since the variation of conductivity with composition is continuous, though not quite linear.

If the heat to be dissipated is higher than can be handled by helium in the thinnest practical annulus, it becomes necessary to employ metal fins that connect the inner crucible and the outer shell. From the viewpoint of heat transfer, the factors important in fin design are thickness, conductivity of materials used, and radial length. One problem introduced by fins is that of obtaining fin-wall joints which do not restrict heat flow or thermal expansion. Furnace-brazing techniques may be used to obtain metallurgically bonded joints. It is usually more satisfactory and much simpler, however, to design for assembly with a light press fit, which provides good thermal contact as the capsule expands on heating. Another minor problem with fins is temperature scalloping, the severity of which can be minimized by dividing the desired amount of heat-transfer material into the maximum number of fins consistent with good fabrication practices.

Factors Related to Temperature Determinations

Ideally, the temperature of an encapsulated heat-generating specimen should be measured by locating a thermocouple exactly at the point of

[3] All limits quoted in this report are engineering estimates of 2-σ limits considering realistic fabrication tolerances, thermal conductivity measurements, and instrumentation precision. In most instances, data are not available for a statistical determination of these limits.

[4] The radiation equation is $Q = Ce\,(T_1^4 - T_2^4)$ where C is a constant, e is effective emissivity obtained by combining the individual wall emissivities into the factor

$$e = \left(\frac{1}{(1/e_1) + (1/e_2) - 1}\right),$$

and T_1 and T_2 are wall temperature levels in absolute degrees.

interest, as at the surface or the center of the specimen. In the great majority of practical cases, however, such placement is not feasible without significantly modifying experimental conditions. In these cases, the temperature at the specimen surface may be calculated if a reference temperature is measured and the heat-transfer conditions between the reference point and the specimen surface are known. This can be seen from the simplified equation.

$$T_s = T_0 + QK \quad \ldots\ldots\ldots (1)$$

where:

T_s = specimen surface temperature,
T_0 = reference temperature,
Q = specimen heat flux, and
K = resistance to heat flow between T_s and T_0, including a geometry factor which takes into account the corresponding length of heat-flow path.

Of course, the accuracy with which T_s can be derived is dependent directly on the accuracy with which the terms in the above expression can be measured or calculated.

Reference Temperature Measurements

Reference temperatures in radiation capsule experiments may be obtained by adhering to fairly standard thermocouple techniques inasmuch as the thermoelectric characteristics of common materials such as chromel, alumel, copper, and constantan are not particularly affected by reactor radiation. High-temperature alloy-sheathed ceramic-insulated thermocouple assemblies are particularly useful since they are commercial items, available in sizes as small as a sheath diameter of 40 mils. It is good practice in capsule work to locate the reference temperature thermocouples as close as possible to the specimens. In this way T_0, a directly measured value, is large compared with QK, which is obtained indirectly. In a double-walled capsule, it is advantageous to locate thermocouples in the space between the specimen and the inner crucible. Close proximity to the specimen is thus achieved and, if a molten metal is present in the space, the couples are not affected by radiant heat. By using calibrated wire and precision instrumentation, the estimated 2-σ limit in T_0 may be as low as ± 2 F.

Reference Temperature Location

It is of little value to know a reference temperature to ± 2 F if the location of the point of reference is poorly known and is in a large temperature gradient. This is apt to be the situation in an irradiation experiment with a high specimen heat generation. For example, consider the case of a long, cylindrical, fueled specimen, 158 mils in diameter, located in a NaK bath and generating 700 w per in. of length. This is consistent with the data presented in Fig. 1 and the reference capsule design discussed later in this report.

For this situation, the expression for the specimen surface temperature becomes:

$$T_s = T_0 + Q \cdot \frac{1}{2\pi k} \cdot \ln \frac{r_0}{r_s} \quad \ldots\ldots (2)$$

where:

Q = specimen heat per unit length,
k = thermal conductivity of the NaK,
r_0 = radial distance from the centerline of the specimen to the reference temperature location, and
r_s = radius of the specimen at a point opposite the reference thermocouple.

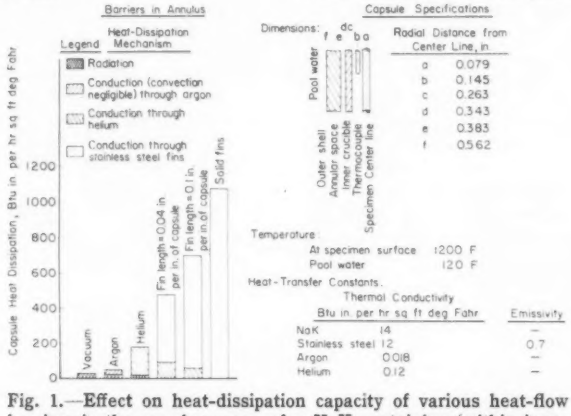


Fig. 1.—Effect on heat-dissipation capacity of various heat-flow barriers in the annular space of a NaK-containing (within inner crucible) double-walled irradiation capsule.

Taking an average value of 14 Btu in per hr sq ft deg Fahr for the thermal conductivity of the NaK, the temperature difference between the specimen surface and the reference thermocouple becomes 198 F. This sizable temperature difference is the result of a high specimen heat flux, a heat-transfer medium of moderately low thermal conductivity, and a small specimen diameter. It is immediately apparent that the four factors Q, k, r_0, and r_s must be known quite accurately or the error in the temperature difference will completely discount the precision with which the reference temperature itself can be measured.

The factor r_0 in the above equation will depend upon: (1) the location of the specimen centerline, (2) the location of the reference thermocouple centerline, and (3) the location of the effective junction within the thermocouple bead. In normal practice, the specimen and thermocouple are supported and located independently from the ends of the capsule. Also, the specimen is allowed some freedom of movement to accommodate dimensional changes that accompany radiation damage. During capsule assembly and welding operations, the specimen and thermocouple can be expected to shift their positions somewhat; during the temperature rise to the operating level and as a result of radiation damage to the specimen, more distortion and changes in the location of the specimen and thermocouple can be expected. Under these circumstances, it is difficult to specify the location of the thermocouple with respect to the specimen centerline any closer than ± 25 mils.

Not as obvious but of considerable importance is the uncertainty in the location of the effective thermocouple junction within the thermocouple bead. Unless carefully carried out, the common practice of fusing the thermocouple wires and the sheath together to form a bead can leave considerable doubt as to the location of the point at which the temperature is sensed. However, with care in forming the junction and radiographic inspection of the result, it is possible to establish the location of the junction with respect to the thermocouple centerline within ± 3 mils.

Combining these limits, we have a 2-σ limit of just slightly over ± 25 mils for r_0.[5] This by itself would create limits of ± 56 F or about ± 28 per cent for the temperature drop from the specimen surface to the reference thermocouple.

The variation in r_s is more difficult to predict. For the specimen under consideration, a fabrication tolerance of only $\pm \frac{1}{2}$ mil on the radius is specified. The only significant change in r_s will be an increase in diameter as a result of radiation damage. This is very difficult to treat in a manner similar to the other uncertainties since the change will always be in one direction and will

[5] Throughout this report, the estimated 2-σ limits are combined by the usual methods of finding the square root of the sum of the squares of the individual limits. The results can only be considered as engineering estimates since the individual limits are only estimates and the method of combination assumes, for lack of data, a normal distribution of values.

vary with the type of specimen and time rather than as a random variation. Therefore, this analysis will treat the uncertainty in r_s separately by finding the effect of the temperature measurement of a specified change in diameter during the experiment. For the specimen under consideration, a 5 per cent change in diameter will cause an 8 per cent change in the 198 F temperature difference, which will mean an error of 16 F in the predicted surface temperature.

Heat-Flow Determinations

The temperature drop from the specimen surface to the reference temperature thermocouple is also dependent upon Q, the specimen heat flux. As has been explained in a previous section, the specimen heat will vary directly with the specimen fuel loading and the average thermal neutron flux. The fuel loading can be controlled very closely. However, the neutron flux (and the specimen heat unless it is measured directly) will be uncertain to ±20 per cent until the experiment is completed and the dosimeter wires can be examined. This is too late to be of use in calculating and controlling the specimen temperature. The ±20 per cent estimated 2-σ limit for Q alone would mean an estimated 2-σ limit of ±40 F in the specimen surface temperature.

A method of measuring heat flow directly and continuously during the irradiation exposure is proposed. It is believed that an applicable scheme is to use a differential thermocouple spanning a simple heat-flow path having precisely known thermal characteristics. One way would be to locate two thermocouples at different distances from the specimen in the NaK bath. However, thermocouple locations are usually subject to the uncertainties previously described. A better method of achieving the desired result is to install a differential thermocouple within a capsule wall so that it can measure a radial temperature difference across a well-defined distance of homogeneous material. While this distance may be short and the temperature drop correspondingly small, this limitation can be more than offset by the accuracy with which the thermocouple locations can be ascertained and with which the pertinent heat-transmission constants can be established. Furthermore, a single set of calibration data for a standardized heat-flow meter of this type can suffice for a variety of capsule applications. The design details of a typical device incorporated in a double-walled capsule are presented as part of a reference design described in a subsequent section.

It should be pointed out that, in order to arrive at a fission heat-generation rate, two types of corrections must be applied to any physical measurement of radial heat flow. One is the subtraction of that fraction of the measured heat flux which is attributable to gamma heating of the specimen and the various capsule components. The second correction involves accounting for

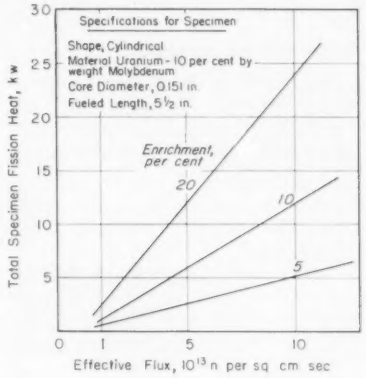


Fig. 2.—Heat-generation-effective flux relation for fueled specimen used in reference design.

end losses (nonradial heat flow). In this connection, it is important to recognize that the radial heat flux may vary along the axis of the capsule as a result of (1) nonuniform neutron flux, (2) axial variation in fuel concentration, (3) the use of fins (temperature scalloping), as well as (4) end losses. In a NaK-containing double-walled capsule, any variations caused by nonuniform fission heat release (items (1) and (2) above) tend to be smoothed out by the NaK. Even so, the use of a number of heat-flow meters spaced along the length of the capsule is desired to provide an indication of whatever axial nonuniformity in heat flux many exist.

Other Factors

The remaining parameter of importance in the expression for the specimen surface temperature is the thermal conductivity of the heat-transfer medium which, in the example being considered, is NaK. Actually, a small amount of convective heat transfer by the NaK must also be considered. However, this is normally very small and can be calculated and corrected. With the best of current techniques, it should be possible to determine the thermal conductivity of NaK to ±5 per cent which, in the situation described, will cause an uncertainty in the specimen surface temperature of about ±10 F.

The foregoing discussions tacitly assume that radial variations in heat flow would not occur. This would be true if the fueled specimen being irradiated had a cylindrical symmetry and if the specimen were irradiated in an isotropic flux. In actual practice, of course, specimens of various configurations and flux patterns of various degrees of asymmetry may be encountered. Each of these presents special problems in the interpretation of specimen surface temperatures from reference temperature and heat-flow data. In fact, as soon as the specimen geometry departs from the ideal cylindrical shape, exact analytical solutions to the heat-transfer equations become difficult or impossible. Hence, when precise predictions of specimen temperature are required, it is necessary to utilize numerical methods or analog techniques.

In the design of an irradiation capsule some steps can be taken to improve the radial symmetry of heat dissipation even though the specimens are noncylindrical. For example, fins can be interrupted in low heat-flux regions, or partial heat-flow barriers can be introduced in high heat-flux regions. Such practices, although difficult to implement without painstaking analytical or trial-and-error preirradiation procedures, can do much toward smoothing out specimen temperature profiles which otherwise would be irregular.

Uncertainty in Specimen Temperature

The uncertainties in the factors discussed in the preceding section and listed in Table I can be combined to find an estimated 2-σ limit for the specimen surface temperature for the example described. The estimated 2-σ limit for the specimen surface temperature is found to be ±70 F as a result of these four factors. To this we may want to add the change of 16 F that would be caused by a 5 per cent change in specimen diameter as a result of radiation damage.

Reference Design

To illustrate how various factors related to heat transfer and temperature measurement can be handled in an actual capsule design problem, a reference capsule was designed with the

TABLE I.—VARIATIONS IN SPECIMEN TEMPERATURE.

	Nominal Value	Estimated 2-σ Limits	Individual Effect on Temperature
Reference temperature measurement	1002 F	±2 F	±2 F
Reference temperature location with respect to the specimen centerline (r_0)	145 mils	±25 mils	±56 F
Heat flow	700 w per in.	±20 per cent	±40 F
NaK conductivity	14 Btu in. hr per sq ft deg Fahr	±5 per cent	±10 F

following basic stipulations:

1. A single uranium-10 per cent by weight molybdenum stainless steel clad cylindrical specimen is to be irradiated with a nominal surface temperature of 1200 F. The dimensions of the specimen are 0.158 in. in outside diameter by $5\frac{1}{2}$ in. long (fueled length); the specimen is clad with 4 mils of stainless steel.

2. The maximum allowable capsule outside diameter is $1\frac{1}{8}$ in.

3. All stainless steel construction is required.

4. A wide range of specimen heat-generations must be accommodated with a single basic design size. Fission heat is dependent on specimen enrichment and ambient neutron flux. For the specimen described above, the dependence of heat generation on flux and enrichment is illustrated in Fig. 2.

With these rules in mind, a NaK-containing double-walled capsule which would be suitable for the reactor exposure envisioned from all viewpoints, including engineering and nuclear, was designed. The various details of the design formulated are presented in Fig. 3. The comments below describe briefly features incorporated into the configuration because of heat-transfer considerations and the need for as precise a determination and control of the specimen temperature as possible.

Auxiliary Heating Element

The design is provided with the auxiliary heating element which is located within the inner crucible space filled with liquid metal. The heater specified is a commercially available unit in which an MgO-insulated Kanthal wire with nickel lead wires is sheathed by a $\frac{1}{16}$-in. outside diameter stainless steel tube 10 mils thick. The rated capacity of the heater that can be fitted into the space available is approximately $1\frac{3}{4}$ kw. Satisfactory furnace-brazing techniques are available for providing high-integrity seals at the points of entry of the heater and the thermocouples into the capsule.

During an actual experiment, the auxiliary heat produced would be regulated by a potentiometer controller actuated by a reference temperature.

Heat-Flow Barrier in Annulus

Figure 1 shows how, for a capsule having fixed boundary temperatures and the same radial dimensions as those of the reference design, a wide range of heat-dissipation rates may be obtained by using various heat-flow barriers in the annulus. In the reference design, the fin dimensions and spacing shown in Fig. 3 provide for the dissipation of approximately 0.7 kw per in. of length (3.85 kw total, exclusive of end losses), assuming that the liquid metal present is NaK.

A convenient way of providing these fins is to machine them integral with the inner crucible body. After the finned inner crucible has been assembled (loaded with liquid metal, specimen, thermocouples, and auxiliary heater) and sealed, it is telescoped into the outer shell assembly, using a light press fit.

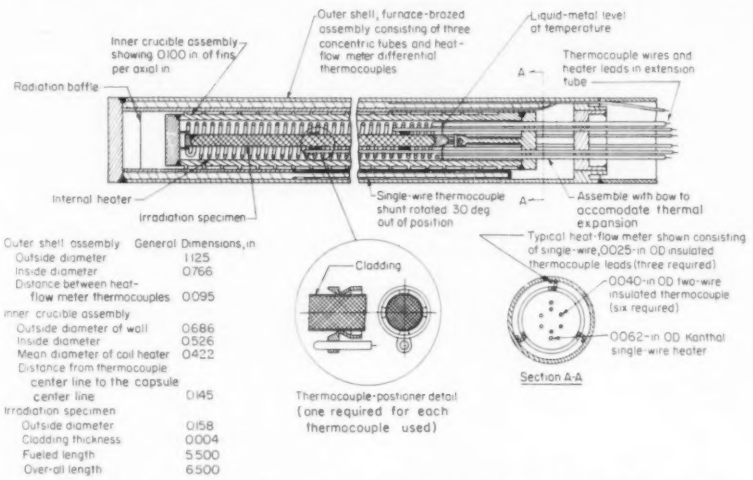
Reference Thermocouples

As is shown in Fig. 3, the six-sheathed chromel-alumel thermocouples provided for reference temperature measurements are equally spaced around the specimens. Their junctions are immersed in the liquid metal, two at each of three levels along the specimen length. To minimize placement uncertainties which, as explained previously, give rise to corresponding uncertainties in specimen temperature, each thermocouple is positively positioned with respect to the specimen. This is accomplished by using special clips (visible in Fig. 3) which hold the thermocouple center line in a fixed distance (~66 mils) from the surface of the specimen. These clips are light enough to prevent any restraint on the specimen upon blistering or swelling. Hot spots will not develop at the contacts because the areas of contact are tiny, and the thermal conductivity of the stainless steel clip is very close to that of NaK.

In a previous section, the uncertainty in the location of the thermocouples was discussed with reference to the centerline of the specimen; in the capsule design discussed in this section, the thermocouple is located with reference to the surface of the specimen. An analysis of the sensitivity of the error in reference temperature to a change in the diameter of the specimen, $2r_s$, from radiation damage shows that, for the design under discussion, the error is much less if the thermocouple-positioning clip is designed to fix the thermocouple-to-specimen surface distance rather than the thermocouple-to-specimen centerline distance. Strictly speaking, Eq 2 should now be written:

$$T_s = T_0 + Q \cdot \frac{1}{2\pi k} \cdot ln \frac{(r_0 - r_s) + r_s}{r_s}, \text{ or}$$

$$= T_0 + Q \cdot \frac{1}{2\pi k} \cdot ln \left(\frac{r_0 - r_s}{r_s} + 1 \right) \quad (3)$$


Outer shell, furnace-brazed assembly consisting of three concentric tubes and heat-flow meter differential thermocouples
Liquid-metal level at temperature
Inner crucible assembly showing 0.100 in. of fins per axial in
Thermocouple wires and heater leads in extension tube
Radiation baffle
A
Internal heater
Irradiation specimen
Single-wire thermocouple shunt rotated 30 deg out of position
Assemble with bow to accomodate thermal expansion
Typical heat-flow meter shown consisting of single-wire, 0.025-in OD insulated thermocouple leads (three required)
Cladding
0.040-in OD two-wire insulated thermocouple (six required)
0.062-in OD Kanthal single-wire heater
Section A-A
Thermocouple-positioner detail (one required for each thermocouple used)

Outer shell assembly	General Dimensions, in
Outside diameter	1.125
Inside diameter	0.766
Distance between heat-flow meter thermocouples	0.095
Inner crucible assembly	
Outside diameter of wall	0.686
Inside diameter	0.526
Mean diameter of coil heater	0.422
Distance from thermocouple center line to the capsule center line	0.145
Irradiation specimen	
Outside diameter	0.158
Cladding thickness	0.004
Fueled length	5.500
Over-all length	6.500

Fig. 3.—Details of a reference design of an irradiation capsule with an internal heat-flow meter. All parts except purchased components to be of type 304 stainless steel.

The use of clips will reduce the uncertainty in the thermocouple centerline-to-specimen surface distance to an estimated 2-σ limit of ± 5 mils or less. Combining this with the ± 3-mil limit for the location of the junction within the thermocouple bead gives a 2-σ limit for $r_0 - r_s$ of ± 6 mils and for $T_s - T_0$ of ± 7 per cent or ± 14 F, if there is no change in the specimen diameter.

The effect of a change in specimen diameter, $2r_s$, is calculated separately since, as mentioned previously, it is unidirectional and somewhat more predictable than the other, more randomly occurring, uncertainties. A change of 5 per cent in r_s, assuming $r_0 - r_s$ is fixed by the thermocouple-positioning clip, will introduce an error of 3.8 per cent in $T_s - T_0$ and 8 F in the specimen-surface-temperature determination.

Differential Thermocouples for Heat-Flow Measurement

The differential thermocouples in the reference capsule are present to provide the means of obtaining direct measurements of radial heat flow. Three such devices are present—one at a location opposite the top portion of the specimen, one opposite the midpoint, and one

opposite the bottom. Each heat-flow meter consists, in essence, of a pair of chromel-alumel thermocouples buried in the outer shell, with their junctions separated by 95 mils of stainless steel in the radial direction. They are connected so that their emf's oppose each other, the net output indicating the radial temperature drop across the span. For a radial heat flow of 700 w per in. of capsule length, the differential temperature would be about 80 F.

One method of simplifying the incorporation of these differential thermocouples into the outer shell assembly is to use three carefully fitted concentric cylinders telescoped together and furnace-brazed. Before final assembly, axial grooves to accommodate the individually sheathed chromel and alumel wires are milled into the outer surfaces of the inner and central cylinders. These surfaces are then given a thin copper plate, the copper acting as the braze in the final assembly to insure a continuous radial heat-conduction path. Prior to telescoping the cylinders together, the sheathed and beaded chromel and alumel wires are laid into their grooves so that after brazing the sheath and bead are metallurgically bonded to sides and bottoms of the grooves. Thus, in place of the customary beaded thermocouple junctions, each junction is actually formed by a tiny, isothermal, circumferential span of stainless steel between the chromel and the alumel wires. The location of such a junction can be established by X-ray techniques to within a few mils and thus is well defined.

For maximum reliability, the differential-thermocouple heat-flow meter must be calibrated to provide a basis of correction for uncertainties such as end losses and gamma heating. With varying known inputs to the auxiliary heater, the relation between measured heat and gross heat input can be established. In the case of the reference design, a calibration corresponding to the entire fission heat range anticipated would not be possible because of the limited capacity of the auxiliary heater provided. Calibration points up to the maximum capacity of the heater would be obtained, and the calibration in the upper range would be an extrapolation from these values. Such an extrapolation could be made with confidence since there is no reason to expect discontinuities in the calibration curve. If desired, a correction for gamma heat can be made on the basis of an in-pile calibration with an unfueled specimen. While prompt gamma rays could not be produced in such a situation, their contribution would be small if they were present.

By establishing the thermocouple junction locations precisely and by taking into account corrections for end losses and gamma heating, it is believed that fission heat can be derived from differential-thermocouple measurements within ±5 per cent without undue difficulty.

TABLE II.—VARIATIONS IN SPECIMEN TEMPERATURE FOLLOWING USE OF REFERENCE DESIGN.

	Nominal Value	Estimated 2-σ Limits	Individual Effect on Temperature
Reference temperature measurement	1002 F	±2 F	±2 F
Reference temperature location with respect to the specimen surface ($r_0 - r_s$)	66 mils	±6 mils	±14 F
Heat flow	700 w per in.	±5 per cent	±10 F
NaK conductivity	14 Btu in. per hr sq ft deg Fahr	±5 per cent	±10 F

Uncertainties in Temperature and Heat-Flow Measurements

In a previous section, an analysis was presented of uncertainties in specimen surface temperature in a sample capsule having radial dimensions matching those of the reference design shown in Fig. 3. For a heat flow of 700 w per in. in a NaK-filled capsule the estimated 2-σ limit for the specimen surface temperature was ±70 F, neglecting a change in specimen diameter from radiation damage. In essence, the purpose of the reference design was to devise a configuration which would reduce this uncertainty significantly. This has been accomplished by (1) reducing the uncertainty resulting from the location of the reference temperature point from ±28 per cent to ±7 per cent, and (2) reducing the uncertainty in the heat generated in the specimens from ±20 per cent to ±5 per cent. If all of the uncertainties in the factors governing the determination of the specimen surface temperature in the reference capsule (Table II) are combined, the estimated 2-σ limit for the specimen surface temperature is ±20 F. This is to be compared to the value of ±70 F previously obtained.

It should be noted that the temperature determination will still be affected by a change in r_s, the specimen radius, from radiation damage. However, because of fixing the thermocouple with respect to the specimen surface with a positioning clip, a change in diameter of 5 per cent will introduce an error of only 8 F in the determination of specimen surface temperature rather than the 16 F error obtained without a clip.

References

(1) J. E. Whitney, E. M. Chandler, J. E. Gates, and G. D. Calkins, "A Radiation Effects Program," Symposium on Radiation Effects on Materials, Vol. 1, Am. Soc. Testing Mats., p. 27 (1956). (Issued as separate publication *ASTM STP No. 208.*)

(2) R. J. Schiltz and D. R. Patterson, "Fuel Irradiation Test Facilities," Nuclear Engineering and Science Conference Preprint 116, March, 1958.

(3) W. B. Lewis, "Isotope Production: How to Choose Irradiation Time," *Nucleonics*, Vol. 12, p. 10, Oct., 1954.

The Use of Ultrasonics in the Testing of Irradiated Fuel Elements[1]

By JOHN M. FOUTS

The application of ultrasonic techniques in nondestructively locating and identifying unbonded areas between the uranium core and aluminum can of Hanford irradiated fuel elements is presented. Details of the underwater equipment and the electronic components are described as well as results of testing.

THE VERSATILITY and usefulness of ultrasonics as a tool for the nondestructive testing of metals has been well established. Many objectionable discontinuities existing in metals such as cracks, voids, laminations, and porosity are subject to detection and location by ultrasonic techniques. The method generally utilized is the detection of a distinct echo when sound energy is reflected from a flaw contained in the metal being tested. An interesting and different method is the use of this pulse-echo principle in the detection of unbonded areas located in the uranium interface or can wall interface of irradiated fuel elements.

Prior to irradiation, the fuel elements of the Hanford reactors are subjected to numerous nondestructive tests. One of these is an assay of the bonded area between the uranium slug and its aluminum can. Only those fuel elements meeting rigid specifications are sent to the nuclear reactors for irradiation.

Major research and development programs are being pursued at Hanford with the aim of developing fuel elements which will better withstand the rigors of irradiation. Elaborate facilities have been constructed which permit personnel to perform numerous studies upon the highly radioactive elements after their discharge from the reactors. One of these laboratories is the Metal Examination Facility which utilizes water as a shielding medium, thus permitting greater flexibility than is normally found in hot cells or lead caves.

This paper describes the application of preirradiation ultrasonic bond testing to irradiated fuel elements. Data are being collected to determine whether or not the bonded layer between the uranium slug and the aluminum can is affected by irradiation. In addition the question of whether or not there is a correlation between unbonded areas and localized hot areas on the slug's circumference could well be answered.

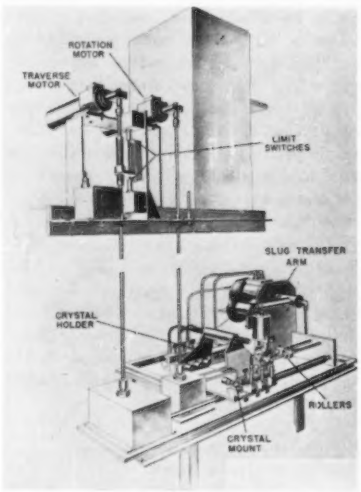


Fig. 1.—Ultrasonic test equipment.

Equipment and Technique

Underwater Equipment

The radioactivity of fuel elements discharged from the Hanford reactors may approach 1,000,000 r per hr. This intense radioactivity requires the use of remotely operated equipment and adequate shielding to protect operating personnel. Since water is used as the shielding medium in our facility, corrosion-resistant materials (stainless steel, bronze, and brass) for all underwater equipment must be used. Electric motors transmitting motion to parts under water are located above the water at platform level. Electric wiring to the pulse-echo ultrasonic crystal is completely waterproofed by encasing it in neoprene tubing.

The underwater equipment for bond testing consists of a manipulator placed 10 ft under water upon which a cylindrical slug may be placed on rollers and rotated at 180 rpm (Fig. 1). A crystal holder and mount is incorporated into the equipment in such a manner that the slug can be scanned longitudinally while it is rotating at a rate of $\frac{1}{16}$ in. per revolution. Auxiliary equipment consisting of a transfer arm and hydromotor is used to place the slug on the manipulator rollers and remove it after scanning. Appropriate indicating dials located at the console permit the determination of the exact location of the crystal with respect to the fuel element.

The bond tester operates on the pulse-echo principle. High frequency energy is sent through a water path into a slug for a short time duration followed by a pause, and then the echo generated is picked up. This cycle of events is repeated at a convenient rate. The manner in which the echoes reveal underlying unbonded areas is different from the usual concept of sound energy reflected from a flaw as a distinct echo. The proximity of the unbonds to the surface of the can and the fact that an echo is reflected from the slug's outer surface as well as the unbond surface prevents a time separation of the respective echoes. The impinging ultrasonic pulses attempt to drive the can wall into forced vibrations in much the same manner as a blow vibrates the head of a drum. If the following two conditions are satisfied, the can wall will vibrate when struck by the ultrasonic pulse: (1) There exists no energy-dissipating condition at the can wall inner surface; that is, it is unbonded; and (2) the frequency of the

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Presented at the Fifth Nuclear Congress, Cleveland, Ohio, April 5 to 10, 1959.

J. M. FOUTS entered the nuclear field in 1948 with General Electric Co. Served as Supervisor of Analytical Control Laboratory, Contact Engineer for the Hanford Laboratory Area, Administrative Assistant to a Division Head, and, since 1953, as Supervisor, Component Testing Unit. Present responsibilities are research and development activities, relating to the effect of irradiation on fuel elements, process tubing, and pressure monitoring systems.

driving pulse matches the resonant frequency of the can wall. The can forms, in effect, an acoustical transmission line analogous to an electrical transmission line, with the unbond representing an open circuit at its termination. Such a line has harmonic resonant frequencies which depend upon its velocity of propagation and its length, in this case the thickness of the can.

Consider now what happens immediately following the termination of the driving pulse. If it were the proper frequency and if it struck the can over an unbond area, forced vibrations would be established in the system. This vibrational energy would then be retransmitted to the water, since under the above assumptions the only other place it can be dissipated is the can wall itself, and those losses are small. Under the bonded condition, however, the can wall cannot vibrate, and there is no energy stored for retransmittal. The manner in which these effects alter the shape of the echo pulse is shown in Fig. 2, with time increasing toward the right. The upper trace is the bonded case and shows energy being reflected only for the duration of the driving pulse, while the unbonded case of the lower trace shows the retransmitted energy of the vibrating can wall as it exponentially decays. This energy, appearing at a time later than that of the driving pulse, furnishes a means whereby unbonded areas are detected.

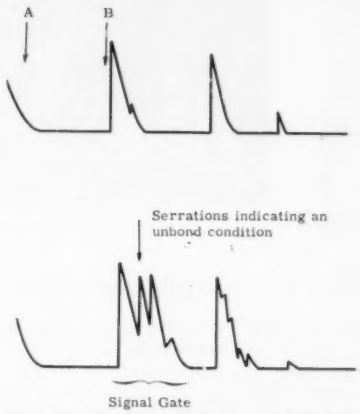


Fig. 2.—Photograph showing an ultrasonic echo from a canned slug. Upper trace is for a bonded slug; lower trace is for an unbonded slug.

Electronic Components

Ultrasonic signals are both generated and detected by a single quartz transducer cut to a disk $\frac{3}{8}$ in. in diameter and 0.006 in. thick for a resonant frequency of about 20 mc. This transducer is driven at a pulse repetition rate of 3000 per sec, resulting in 18 interrogations per cm or 0.02 in. per interrogation. The scanning rate is 1.0 sq in. per sec for a testing time of 40 sec per 8.9-in. slug. Figure 3 is a block diagram illustrating the scanning technique and electronic components. The waveforms in the figure exemplify how the unbond and bond conditions appear to the instrument at various points along the route. The "pip" at the far right is the transmitted pulse, and the first slug echo appears near the center of the trace. Down to and including the gate each waveform is repeated at the interrogation rate of 3000 per sec. The unbond signals at the gate are isolated to reject the slug through either of two discriminator units, A or B. The purpose of these circuits is to cause the ultrasonic instrument to ignore, to different degrees, small porosity, and reject only those slugs failing to meet a specification of localized or cumulative unbonded areas exceeding $\frac{3}{4}$ sq cm measured circumferentially.

The rejection level in discriminator A, the more stringent of the two, is simply the sum on an electronic counter of the total number of affirmative replies received over the total area of the slug. Three-fourths of a square centimeter is equivalent to 65 counts. The circuit of discriminator B operates to reject those slugs possessing a localized unbonded area having a dimension greater than $\frac{3}{4}$ sq cm as opposed to the summation of distributed areas under circuit A. This device performs a time integration of the unbond echoes with respect to slug rotation, and measures the count rate instead of total count.

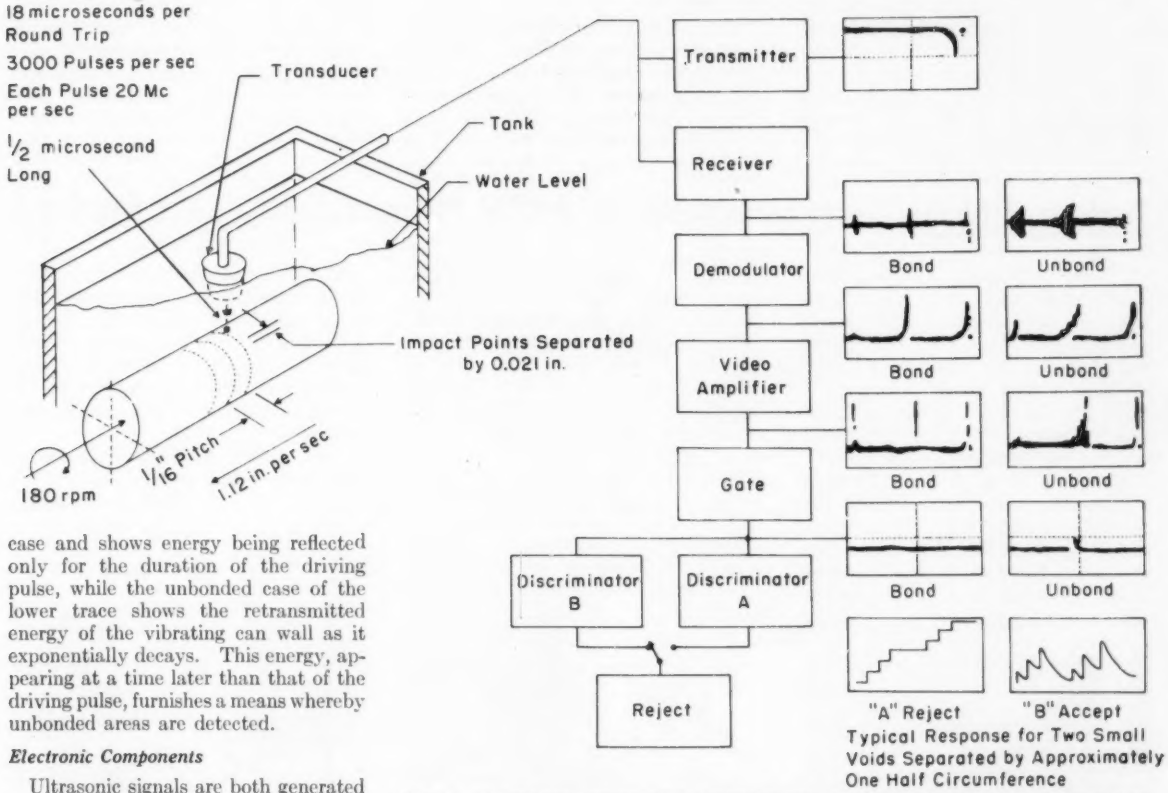
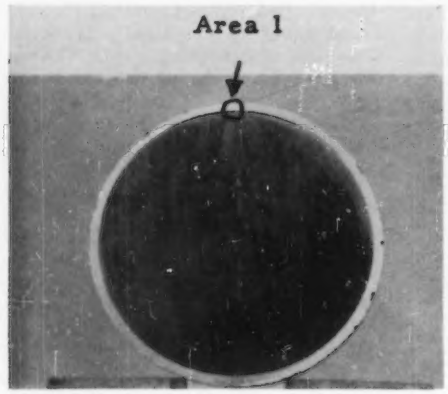


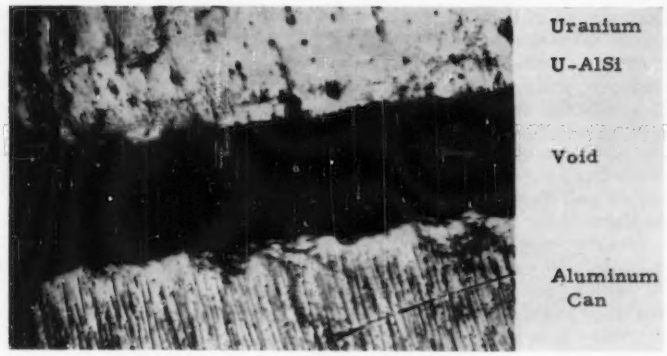
Fig. 3.—Sketch showing scanning technique and waveforms illustrating function of electronic block diagram.

Calibration

Calibration of the instrument is performed twice daily. The standard used is an aluminum canned uranium



(*a*) **Cross-section of slug showing unbonded area.**



(*b*) **Photomicrograph of Area 1 in (*a*).**

Fig. 4.—Cross-section of slug showing unbonded area and photomicrograph of area 1.

slug containing two unbonded areas each 3.8 cm in length, one measuring 0.60 to 0.65 cm in width and the second measuring 0.75 cm in width. The first area will be accepted by the instrument whereas the second area will be rejected.

Test Results

One of the first irradiated fuel elements tested was found to contain an unbond area extending $3\frac{1}{2}$ in. along the slug length and $1\frac{1}{2}$ in. circumferentially. This slug was sectioned at the center of the area in question in our Radiometallurgy Laboratory and Fig. 4(*a*) portrays the unbonded area. Figure 4(*b*) is a photomicrograph taken at the circumferential center of the unbonded area and the void was approximately 9 mils wide. Sectioning of other slugs at areas which the ultrasonic instrument indicated as being unbonded further confirmed the accuracy of the equipment.

Conclusion

Ultrasonics has proved to be a feasible method of nondestructively determining the extent of unbonded areas between the uranium core and aluminum cladding of fuel elements discharged from the Hanford nuclear reactors. The aluminum can conducts the heat generated in the slugs to the cooling water as well as acting as a corrosion barrier preventing contact of the uranium metal and cooling water. Because the corrosion rate of aluminum increases with water temperature, adequate bonding must prevail during irradiation to prevent localized hot areas which may result in cladding failure.

Postirradiation bond testing augments research and development studies regarding the stability of the bond and possible correlation of bonding and localized hot areas found on irradiated slugs.

Technical Note Improvements in ASTM Flammability Test Method

Testing of large numbers of specimens, some from experimental materials with suspected toxicity hazard, suggested a need for refinements in the apparatus and procedure of ASTM Method of Test for Flammability of Rigid Plastics Over 0.050 in. in Thickness (D 635).[1] See Figs. 1, 2, and 3 showing the improved equipment.

Specimens up to $\frac{1}{2}$ in. in thickness are simultaneously clamped at the specified 45-deg angle and distance above the wire gauze. The lip of the support provides a rest for the bunsen burner, thereby reducing the guesswork of positioning. A clothes-pin type clamp holds Kleenex strips for detection of air currents. The pan of water beneath the screen catches any flaming drippings not held by the screen. At the conclusion of the test, carbon dioxide, nitrogen, or air is blasted through the manifold to snuff out the flame.

[1] 1958 Book of ASTM Standards, Part 9, p. 382.

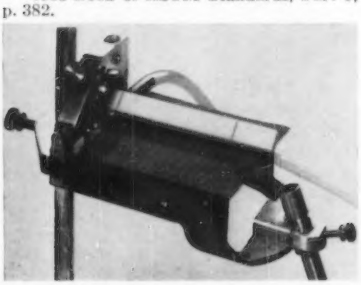


Fig. 1.—Modified apparatus with specimen.

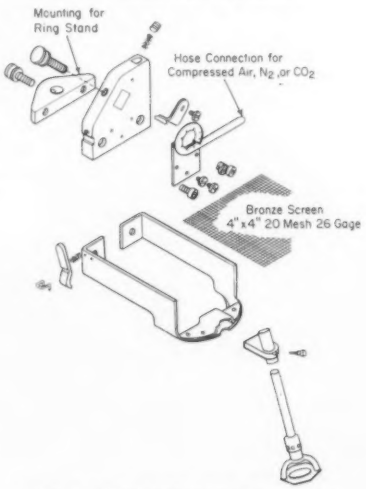


Fig. 2.—Exploded view of apparatus.

The test is conducted in a laboratory hood. After the burning is started, the hood window is closed. All controls are operated from outside of the hood. At the conclusion of the test, the flame is blown out and the exhaust fan is turned on to remove products of combustion.

Dimensioned drawings of this equipment are available on request.

G. E. Eysenbach
J. J. Gouza
Rohm & Haas Co.,
Bristol, Pa.

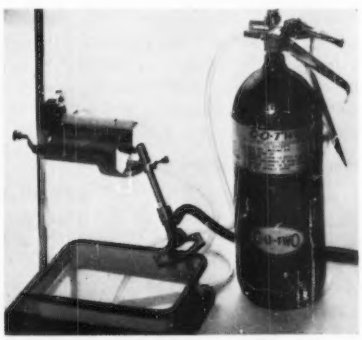


Fig. 3.—Complete test setup.

Control of Thermal History of Polyethylene Test Specimens

By A. M. BIRKS and A. RUDIN

IT HAS BEEN known for some time that the physical properties of solid polyethylene are affected by its thermal history. The magnitude of these effects and the serious variations in physical test data which can result from changes in the heat history of test specimens are rather less well known. Table I illustrates the strong influence of variations in the molding and post-molding treatment of polyethylene test pieces. These data, from environmental stress cracking, brittleness temperature, density, and Izod impact tests, show that the effect of variations in thermal history can be very large. It can sometimes completely overshadow the influence of melt index and density, although these two parameters are often the only ones used to assess the suitability of a polyethylene resin for different applications. It is evident, also, from Table I, that the effect of a particular change in thermal history will depend on the property and the polyethylene sample being tested. The figures suggest that the well-known poor interlaboratory agreement of some mechanical tests on polyethylene may be due in large measure to inadvertent or uncontrolled differences in the thermal history of test specimens.

These large changes in physical properties are apparently due to the influence of the thermal history of the sample on its texture (1),[1] where texture refers to relative proportions of crystalline and amorphous material (reflected in the density), spherulite size, and degree of order and strain at crystallite and spherulite boundaries. Changes in texture appear to affect the behavior of polyethylene in mechanical tests, especially where rupture of specimens is involved.

Nearly all ASTM tests for physical properties of polyethylene are carried out on compression-molded specimens. The mechanical properties of polyethylene are usually measured either to compare different samples or to predict the properties of finished articles. Both these objectives can be confused by the effects illustrated above. For the precise comparison of different polyethylenes, the test data should be measured on specimens with standard thermal histories. Further, if one laboratory is to obtain results that other groups can reproduce, the specimen molding conditions, and particularly the rate of cooling from the melt, must be the same at all locations.

When attempting to predict the behavior of polyethylene articles one should note that heating and cooling cycles vary with different forming methods. For example, molten polyethylene is cooled very rapidly during high-speed extrusion of thin-wall cable coatings or injection molding of thin-wall items. By comparison, a relatively thick submarine cable jacket is cooled very slowly. The properties of these articles can differ not only because different polyethylenes were used in their manufacture but also because of differences in their thermal histories.

This paper describes a method for preparing polyethylene test specimens with controlled thermal histories after molding. As a result, the effect of molding variations can be minimized and the influence of thermal history on physical properties of the specimen can be estimated.

Alternative Methods for Elimination of Molding Variations

One solution to the problem of interlaboratory reproducibility of physical test data would be the specification of a carefully controlled compression-molding method. Considerable experience at our own and other laboratories has shown, however, that it is impractical to try to maintain uniform compression-molding practices between laboratories, since the arrangements for heating and cooling the presses are neither completely similar nor amenable to precise enough control. It has even been found difficult to mold reproducibly on a single press, although this is a serious problem only where the tests concerned are very sensitive to variations in thermal history. Examples of such tests are environmental stress cracking and Izod impact strength of types II and III[2] polyethylenes. It is therefore necessary to include a post-molding conditioning step in the specimen-preparation method in order to produce test specimens with a standard thermal history independent of the original, relatively uncontrollable compression-molding cycle. Without this conditioning, the comparison of different resins will be confused and the interlaboratory variance of test results will be swollen by the unpredictable effects of molding variations.

Immersion for various lengths of time in boiling water is very frequently used as a method for removing variations due to molding (2), but this conditioning method is not entirely satisfactory as is shown in the results of round-robin trials, within our company, of the test methods for measuring the density and brittleness temperature of polyethylene. Part of these results are given in Tables II and V. These figures show that annealing in boiling water is not reproducible between different laboratories and does not erase molding variations. The ineffectiveness of conditioning in boiling water stems apparently from its failure to reach the crystal melting point of polyethylene and to include a precise cooling rate.

ALECK M. BIRKS received his B.A. and M.A. degrees from the University of Toronto. After war service as technical officer, Chemical Warfare, Canadian Army, he joined the Central Research Laboratory of Canadian Industries Limited in 1946. In recent years he has headed a group specializing in evaluation of plastics, principally polyethylene. He is active in ASTM Committee D-20 on Plastics.

ALFRED RUDIN received his B.S. degree from University of Alberta and Ph.D. from Northwestern University. He joined the Central Research Laboratory of Canadian Industries Limited in 1952, and has spent the past three years in polyethylene research.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] ASTM Specification for Polyethylene Molding and Extrusion Materials (D 1248 – 58 T) 1958 Book of ASTM Standards, Part 9, p. 48.

There must be two stages to a satisfactory conditioning procedure. In the first place, the material must be heated for some time at a temperature at or above its crystal melting point to erase the existing texture. Secondly, it must be cooled from the melt at a precisely controlled rate. It is also important to maintain dimensions of the molding during the conditioning cycle so that uniform test specimens can be produced for the subsequent mechanical tests.

Following is a description of a specimen preparation method which meets the above requirements and results in improved interlaboratory agreement of test results on solid polyethylene.

Conditioning Method

The conditioning method starts with the compression-molding operation,[3] where a picture-frame mold and relatively heavy aluminum foil parting sheets are used. The aluminum foil (0.005 in. thick) adheres quite tightly to the polyethylene and mold so that the frame, molded plaque, and parting sheets can be handled easily as a unit. After pressing, the polyethylene plate, which is still inside the frame and between the adhering aluminum foils, is placed in a forced draft oven operating about 20 C above the melting point of the plastic. After 1 hr in the oven, the molded-in texture of the polyethylene has been erased. There is sufficient adhesion between the polyethylene and the relatively stiff aluminum foil to retain the original dimensions of the molded plate.

The next phase of the conditioning cycle comprises cooling the specimen to room temperature at a precise rate to impose a standard, reproducible texture on the solid material. This cooling rate is open to choice, within limits, and it was decided to adopt two standard cooling rates, one slow and the other fast for reasons which are discussed below in the section on Significance of Test Results.

The slow-cooling rate was chosen to be 5 C per hour. It can be shown that the density of polyethylene is strongly affected by the rate at which it has been cooled from the melt; the slower the rate, the higher the density. The density tends toward an asymptotic value, but equilibrium is not attained even at cooling rates as slow as 1 C per hour. A rate of 5 C per hour was chosen on the grounds of convenience (cooling can be completed in an overnight operation), with the assumption that the texture produced would be reasonably close to that of the equilibrium state that would obtain from infinitely slow cooling.

[3] Detailed instructions for the preparation of compression-molded test specimens according to this method and plans for a reliable temperature controller for slow cooling may be obtained from the authors. The method is being studied by a task group of ASTM Committee D-20 on Plastics.

TABLE I.—EFFECT OF THERMAL HISTORY ON MECHANICAL PROPERTIES OF POLYETHYLENE.

(*a*) Environmental Stress Cracking

Sample[a]	Specimen Molding Conditions	Postmolding Treatment	Test Conditions[b]	Crack Resistance[d]
A (type I)	Normal[c]	None	20 per cent Hostapal HL—50 C	No failures in 9 days
A	Normal[c]	Cooled from 135 C at 5 C per hr	20 per cent Hostapal HL—50 C	F_{50} = 5 hr, 100 per cent failures in 8 hr
B (type I)	Normal[c]	None	20 per cent Igepal CO630—30 C	F_{50} = 11.5 hr
B	Cooled in press from 150 C to 80 C in 30 min	None	20 per cent Igepal CO630—30 C	F_{50} = 3.3 hr

(*b*) Brittleness Temperature[e]

Sample[f]	Postmolding Treatment	Brittleness Temperature, F_{50} deg Cent
C (type I)	None	−18 (notched specimens, (3))
C	1 hr in boiling water	−12 (notched specimens, (3))
D (type I)	None	−65
D	30 min in boiling water	−34
E (type I)	None	−85
E	30 min in boiling water	−46

(*c*) Brittleness Temperature and Density[g]

Sample	Molding Conditions			Brittleness Temperature, F_{50}, deg Cent	Density, g per ml
	Platen Pressure, psi	Temperature, deg Cent	Cooling rate in press[a]		
No. 1 (melt index 7)	16 000	130	Fast[h]	−30.0	0.9180
	16 000	160	Slow[i]	−21.6	0.9188
No. 2 (melt index 2)	8 000	160	Slow[i]	−35.0	0.9207
	16 000	130	Fast[h]	−46.5	0.9194

(*d*) Izod Impact Resistance[j]

Sample	Postmolding Treatment	Impact Resistance of ¼-in. Specimen
F (type II)	Cooled very rapidly from melt	16 in-lb, incomplete break
F	Allowed to cool from melt to room temperature in about 3 hr	1.0 in-lb, specimens completely ruptured

[a] Sample type refers to sample density, according to ASTM Specification D 1248 – 58 T.
[b] Cracking agents listed here are commercial wetting agents.
[c] Cooled in press from 150 C to 75 C in 7 min.
[d] F_{50} = time for failure of 50 per cent of specimens.
[e] ASTM Method D 746 – 57 T.
[f] All samples molded under the same conditions, so far as possible.
[g] ASTM Method of Test for Measurement of Density of Plastics by the Density-Gradient Technique (Tentative) (D 1505 – 57 T), 1958 Book of ASTM Standards, Part 9, p. 511.
[h] Molding cooled in press to 50 C in less than 3 min.
[i] Molding cooled in press to 80 C in about 25 min.
[j] ASTM Method of Test for Impact Resistance of Plastics and Electrical Insulating Materials (D 256 – 56) 1958 Book of ASTM Standards, Part 9, p. 284.

The fast cooling rate was not measured *per se* but was defined as the quenching of a molten sample in cold water under standard conditions.

During slow-cooling, the molded material in the picture frame and between the aluminum foil parting sheets, can be left in the forced draft oven in which it has been heated. In our laboratory the temperature of the oven is decreased by 5 C per hour by a motor driving the set point of a mercury thermoregulator which controls the oven heater. Slow-cooled conditioning usually consists of cooling moldings of type I polyethylene[2] from 140 C to about 60 C and is an automatic, overnight operation.

Fast-cooling is carried out by removing a hot molding, complete with mold and foil parting sheets, from the oven and quickly plunging it into a tank of running cold water. This operation can be carried out reproducibly without undue difficulty.

After either slow- or fast-cooling, the aluminum foil parting sheets are stripped off and the polyethylene sheet is knocked out of the picture-frame mold and cut to the required dimensions for the subsequent tests.

Characteristics of Conditioned Test Specimens

Agreement of Test Results Between and Within Laboratories

It is shown below that both conditioning procedures are reproducible and both effectively eliminate the results of wide variations in compression molding conditions. The between-laboratory agreement of mechanical tests is very mark-

TABLE II.—EFFECT OF BOILING WATER CONDITIONING ON DENSITY OF POLYETHYLENE.[a]

Laboratory 1	Laboratory 2	Laboratory 1	Laboratory 2
SAMPLE A			
pressed			pressed
annealed	annealed	annealed	annealed
0.9263	0.9272	0.9264	0.9261
SAMPLE B			
pressed			pressed
annealed	annealed	annealed	annealed
0.9204	0.9210	0.9204	0.9200
SAMPLE F			
pressed			pressed
annealed	annealed	annealed	annealed
0.9161	0.9161	0.9160	0.9152

[a] Densities measured by ASTM Method D 1505 – 58 T, in g per cu cm at 23 C.
Note:—For annealing, samples are immersed in boiling water for 1 hr.

of the cracking times of conditioned test specimens. The agreement of these results was very much better than that of the "normal" test, which does not include conditioned test specimens.

The results of a round-robin trial between three laboratories of the stress cracking test using conditioned specimens are given in Table IV (*c*). Statistical analysis of these data for slow-cooled moldings revealed no significant between-laboratory differences at the 95 per cent confidence level. Results from stress-cracking tests on fast-cooled specimens do not agree as well as from slow-cooled samples, but this is almost certainly due to operator error in scoring the results rather than to lack of reproducibility of the shock-cooled conditioning procedure. The agreement of the test data in Table IV (*c*) is admittedly not of a very high order, but even so it is the best, so far as we know that has ever been achieved with this difficult test method.

It is concluded, on the basis of the above evidence, that the method for the preparation of compression-molded test specimens described here erases molding variations and can be performed reproducibly in different laboratories. It appears to be a necessary requirement for the precise performance of almost all tests on compression-molded polyethylene.

TABLE III.—USE OF CONDITIONING TO ERASE MOLDING VARIATIONS.

Sample	Molding Conditions			Brittleness Temperature, F_{50}, deg Cent[a]			Density of Test Specimens		
	Platen Pressure, psi	Temperature, deg Cent	Cooling Rate in Press	As Pressed	Shock-Cooled Conditioning	Slow-Cooled Conditioning	As Pressed	Shock-Cooled Conditioning	Slow-Cooled Conditioning
No. 1 (melt index 7)	16 000	130	Fast[b]	−30.0	−45.2	−9.7	0.9180	0.9142	0.9228
	16 000	160	Slow[c]	−21.6	−43.6	−10.5	0.9188	0.9140	0.9228
	8 000	160	Slow[c]	−23.6	−43.0	−10.4	0.9192	0.9138	0.9228
No. 2 (melt index 2)	8 000	160	Slow[c]	−35.0	−56.0	−17.8	0.9207	0.9151	0.9235
	8 000	130	Fast[b]	−49.0	−57.0	−18.7	0.9194	0.9149	0.9234
	16 000	130	Fast[b]	−46.5	−58.0	−19.5	0.9194	0.9150	0.9236

[a] ASTM Method D 746 – 57 T, notched test specimens (**3**).
[b] Cooled in press to 50 C in less than 3 min.
[c] Cooled in press to 80 C in about 25 min.

edly improved by the use of this specimen preparation method.

For the most part, tests used in evaluating the properties of the conditioned moldings were brittleness temperature (ASTM Method D 746–57 T,[4] using notched specimens (**3**)) and environmental stress crack (**4**) resistance (ASTM 1693–59 T).[5]

The brittleness temperature data in Table III illustrate the use of the conditioning procedure described above to erase the effects of molding variations on two resins which were compression-molded under very different pressures, platen temperatures, and cooling rates in the press. It is evident from these results that the cooling rate in the press exerts a major influence on brittleness temperature, and that either conditioning cycle (fast- or slow-cooled) will bring a molded sheet to a standard condition, regardless of its prior thermal history.

[4] ASTM Method of Test for Brittleness Temperature of Plastics and Elastomers by Impact (D 746 – 57 T) 1958 Book of ASTM Standards, Part 9, p. 355.
[5] ASTM Method of Test for Environmental Stress Cracking of Type I Ethylene Plastics (D 16 93– 59 T) 1959 Supplement to Part 9; 1958 Book of ASTM Standards.

The results of a brittleness temperature round-robin trial, in which three laboratories within our own company participated, are shown in Table IV (*a*). Each group milled, pressed, conditioned, and tested the specimens. These data show good interlaboratory agreement so far as the conditioning method is concerned. Subsequent experience has shown that whatever between-laboratory variation is present in these figures can be reasonably assigned to the test procedure rather than to sample preparation and conditioning. The agreement of the results in Table IV (*a*) should be contrasted with the very poor reproducibility in Table V, which gives values characteristic of work produced by the same laboratories before the introduction of sample conditioning.

It was observed quite early in this work that the within-laboratory agreement of the environmental stress cracking test was markedly improved by the use of conditioned test specimens. Table IV (*b*) gives the results of a trial conducted at one laboratory, in which two operators each performed the complete stress cracking test, from milling and pressing granule samples to observation

Specimen Preparation Time

Specimen preparation according to the method reported here would appear at first glance to be complicated and time consuming compared to standard molding practice. It is not as laborious, however, as it might seem. The conditioning part of the procedure does take time, but this is waiting time (frequently overnight) rather than working time. It should be remembered, also, in this connection, that there is less time wasted in the performance of a test which is both precise and results of which are comparable to those obtained in other laboratories than in performing a test involving rapid preparation of test specimens, the properties of which are of use only at the location where they are molded.

Dimensional Tolerance of Conditioned Specimens

The dimensional tolerance of conditioned specimens is reasonably satisfactory. Examples are given in Table VI for fast- and slow-cooled test specimens. The conditioning procedure has been applied successfully to produce compression moldings with target thicknesses ranging between about 0.06 to 0.125 in.

Thickness control is evidently not so good as could be expected with well-molded plates taken directly from the press. The important point here, however, is that test results on conditioned plates are much more reproducible than on as-molded plates. Fine dimensional tolerances either are not necessary with the particular tests used (brittleness temperature and environmental stress cracking), or else, and more probably, the effect of controlling the texture of the polymer outweighs minor variations in specimen thickness.

Stability of Conditioned Test Specimens

The density, and therefore the texture, of fast-cooled moldings changes with time. Very limited data have not indicated any corresponding changes in brittleness temperature, however, for periods up to two weeks after fast cooling. Slow-cooled conditioning would of course bring polyethylene to a state more nearly invariant with time, but the density of slow-cooled moldings has been observed to change slowly on standing. Evidently the change in any property with time since conditioning will depend on the particular property, conditioning method and, possibly, on the polyethylene sample itself. Until more experience is gained, it is recommended that the time since conditioning be recorded along with the test data on conditioned specimens. Changes observed to date in brittleness temperature and environmental stress-cracking resistance have not been so drastic as to require standardization of the time between conditioning and testing polyethylene specimens.

Extension to Higher Density Polyethylene

The work reported here was largely confined to low-density polyethylene. In this case a conditioning period of 60 min at 140 C is sufficient to melt the resin and erase its thermal history. Higher temperatures are required both in the pressing and conditioning of higher density polyethylenes to promote adhesion of the plastic to the aluminum foil used as a parting agent. For example, type III resins[2] should be pressed and conditioned at at least 160 C.

Significance of Test Results Obtained with Conditioned Specimens

Two conditioning procedures are recommended because the mechanical properties of a polyethylene sample may differ radically and to an unpredictable extent when fast-cooled and slow-cooled specimens are tested. It was felt that a realistic picture of the properties of a resin would require test data from both conditioning schedules. In testing for compliance with specifications, probably only one conditioning method should be used, and that will be the more convenient or appropriate one for the particular test.

When the conditioning method is changed, the corresponding variation in

TABLE IV.—INTERLABORATORY PRECISION OF PHYSICAL TESTS ON POLYETHYLENE SAMPLES COMPRESSION MOLDED BY THE C-I-L METHOD.

(*a*) BRITTLENESS TEMPERATURE[a]

Sample[b]	Cooling Cycle During Sample Preparation	Temperature for 50 per cent Failure, F_{50}, deg Cent.					
		Laboratory 1		Laboratory 2		Laboratory 3	
		F_{50}	σ[c]	F_{50}	σ[b]	F_{50}	σ[b]
B1	Shock-cooled	−40	(2.4)	−35	(1.6)	−35	(2.6)
	Slow-cooled	−2	(5.8)	−6	(2.8)	−5	(2.0)
B2	Shock-cooled	−58	(2.0)	−60	(3.0)	−55	(1.7)
	Slow-cooled	−16	(2.5)	...	...	−16	(1.7)
B3	Shock-cooled	−19	(0.6)	−22	(1.3)	−23	(1.0)
	Slow-cooled	+1	(2.1)	−3	(1.7)	+3	(0.9)
B4	Shock-cooled	−39	...	...	...	−37	...
B5	Shock-cooled	−25	...	...	...	−26	...
B6	Shock-cooled	−13, −15	...	...	...	−13, −14	...
B7	Shock-cooled	−42	...	...	...	−40, −43	...
B8	Shock-cooled	−24	...	...	...	−23	...
B9	Shock-cooled	−41	...	...	...	−39	...
B10	Shock-cooled	−15	...	...	...	−17	...
B11	Shock-cooled	−17	...	...	...	−20	...

(*b*) ENVIRONMENTAL STRESS CRACKING[d]

Sample[b]	Melt Index	Cooling Cycle During Sample Preparation	Test Conditions	Time to 50 per cent Failure	
				Operator A	Operator B
E-1	20	Shock-cooled	C[g]	54 min	52 min
E-2	8	Shock-cooled	B[f]	11 min	9 min
E-3	0.4	Slow-cooled	A[e]	378 min	387 min
E-4	2	Slow-cooled	B[f]	7 min	6 min
E-4	2	Shock-cooled	B[f]	7 days	7 days

(*c*) ENVIRONMENTAL STRESS CRACKING[h]

Sample[d]	Melt Index	Cooling Cycle During Sample Preparation	Test Conditions	Median Stress Crack Failure Time, F_{50}, min					
				Laboratory 1		Laboratory 2		Laboratory 3	
				F_{50}	σ[l]	F_{50}	σ[l]	F_{50}	σ[l]
T-1	2	Slow-cooled	D[i]	7	(1)	7.5	(1)	9.5	(1)
T-2	2	Slow-cooled	E[j]	100	(11)	118	(25)	135	(6)
T-3	0.4	Slow-cooled	F[k]	38.5	(6)	29.5	(6)	36	(6)
T-4	0.2	Slow-cooled	A[e]	18.5	(1)	19	(4)	22	(5)
T-5	0.2	Slow-cooled	A[e]	82	(1)	128	(28)	90	(14)
T-6	2	Slow-cooled	E[j]	...	...	84	(12)	88	(17)
T-7	2	Slow-cooled	E[j]	...	...	195	(36)	211	(37)
T-8	7	Shock-cooled	D[i]	30	(2)	12.5	(8)	16.5	(2)
T-9	20	Shock-cooled	C[g]	50–60	...	139	(15)	94	(11)

[a] ASTM Method D 746 – 57 T, notched test specimens (3).
[b] All samples were type I, according to ASTM Method D 1248 – 58 T.
[c] σ = standard deviation of distribution of failures. It indicates the temperature interval over which transition from ductile to brittle behavior occurred. For all practical purposes, in this case $\sigma = F_{84} - F_{50}$ and is also equal to $F_{50} - F_{16}$ where, for example, F_{84} is the temperature for 84 per cent failures.
[d] Trial between two operators within one laboratory.
[e] 20 per cent aqueous Hostapal HL, 50 C.
[f] Igepal Co 630; 50 C.
[g] 0.25 per cent (W/V) Ivory Snow—0.2 per cent (V/V) tributyl phosphate, 30 C.
[h] Trial between three laboratories.
[i] Igepal Co 630; 40 C.
[j] 0.5 per cent Igepal Co 630; 35 C.
[k] 20 per cent aqueous Hostapal HL, 40 C.
[l] σ = standard deviation of distribution of failures. σ is an indication of the time interval between initiation and completion of environmental stress cracking failures. In this case σ equals $F_{84} - F_{50} = -F_{50} - F_{16}$.

TABLE V.—BRITTLENESS TEMPERATURE TEST, ASTM METHOD D 746, 50 PER CENT FAILURE TEMPERATURE, F_{50}, DEG CENT.

Sample	Laboratory 1	Laboratory 2	
	All Test Specimens Annealed[a]	Annealed Specimens[a]	As Pressed Specimens
A1	−68	−46	−85
A2	−100	−77	−101
A3	−94	−63	−94
A4	−46	−36	−65
A5	−99	−76	−105
A6	−96	−61	−91

[a] Annealing consisted of immersing samples in boiling water for 30 min.

TABLE VI.—DIMENSIONAL TOLERANCE OF CONDITIONED TEST SPECIMENS FOR BRITTLENESS TEMPERATURE TEST, ASTM METHOD D 746 - 55 T.[a]

Sample	Melt Index	Number of Specimens	Mean Thickness, in.	Range, in.
J.....	0.4	102	0.075	0.072–0.079
K.....	1	87	0.074	0.072–0.077
L.....	7	104	0.073	0.069–0.075
M.....	20	95	0.074	0.068–0.078

[a] Thickness of picture frame mold is 0.075 in. Each sample consisted of four 4 by 4-in. plates.

a mechanical property will depend on the resin being tested and on the sensitivity of the particular property to variations in texture. Examples of these effects, which can be very large, are shown in Table VII.

The texture of fast-cooled specimens will be like that of articles which have been cooled quickly after forming by the usual methods of extrusion or injection molding. The density and texture of fast-cooled specimens will not be stable on storage but will gradually change toward that of slow-cooled specimens. The latter will approximate the texture of polyethylene articles a relatively long time after their fabrication by normal methods, or of new articles which have been cooled slowly after forming. Neither conditioning method is intended to be a duplicate of commercial cooling conditions. They are extremes, rather, and the texture of fabricated articles will probably lie between those imposed by our two conditioning procedures. A comparison of the properties of fast- and slow-cooled specimens of the same resin should indicate how articles made from this polymer will tend to change on aging and how they will be affected by variations in cooling as they are formed.

The drastic deterioration in brittleness temperature and stress-crack resistance, with slower cooling, shown in Table VII, should be noted. These are general, not special, cases and differences of these magnitudes will be observed frequently, even with polyethylenes which have given long and satisfactory field service. It would be interesting to know how long articles can be used before their texture and properties become close to that of slow-cooled specimens. The technique of using conditioned test specimens is still in its infancy and we do not have enough information yet to attempt to answer this problem, although it is evident that the conditions of use will affect the texture of a polyethylene article. Preliminary results of an investigation of this matter indicate that temperature should be a particularly important factor, since warmer conditions will result in faster annealing and a more rapid approach to "slow-cooled" texture.

The effect of carbon black might be important in this connection. Polyethylene is compounded with carbon black to improve its resistance to degradation by ultraviolet radiation. Let us imagine two articles formed identically from the same polyethylene resin, the only difference being that one contains carbon black and the other is natural. On exposure to sunlight, the unpigmented article will be degraded by the action of ultraviolet radiation, to which a properly compounded black article should be relatively immune. But the black article will be warmer because the carbon black absorbs much more of the incident light. Thus, after exposure for a while the black article might be annealed more than its natural counterpart and its physical properties might really be worse, although it has not been degraded chemically.

The same considerations can also lead to the confusion of results of weathering tests where attack on the polymer is estimated by periodic measurements of such a property as brittleness temperature. Evidently, if resistance to ultraviolet light is of interest, it would be necessary to test not only the exposed samples but also duplicates which had been given the same thermal history in the dark. An alternative is, of course, to remelt and condition test specimens, but surface degradation cannot be estimated by this procedure.

It should be borne in mind that the main reason for introducing sample conditioning was not to provide the above information but to prevent the confusion of test results by molding variations. A comparison of properties of fast- and slow-cooled samples should help characterize the resin in the manner described above but it does not necessarily tell the whole story.

Caution should be exercised particularly in using the results of impact tests on fast- and slow-cooled specimens to predict service life of polyethylene articles. Nonuniform texture, flow lines, surface defects, and molded-in stresses which affect the properties of extruded or molded objects cannot be duplicated in compression moldings.

Conclusions

1. The thermal history of any polyethylene molding affects its mechanical properties to a considerable and, at present, unpredictable extent.

2. The rate at which a polyethylene molding has been cooled from the melt is the major factor. Variations in rate of cooling can create effects very much greater than those due to changes in melt index, density, etc. Very rapid cooling has a beneficial effect on the results of all tests involving propagation of a crack through the specimens.

3. The conditioning method described provides uniform test specimens suitable for comparison of different polyethylenes.

4. The prediction of the behavior of a polyethylene article requires at least an approximate knowledge of its thermal history during and after its formation from the molten plastic. Even with this knowledge, differences between compression molding and other fabrication methods can make this prediction uncertain.

5. The work reported here was confined entirely to polyethylene. It is likely, however, that other partially crystalline plastics, such as nylon and polypropylene, will exhibit similar effects.

TABLE VII.—DEPENDENCE OF MECHANICAL PROPERTIES ON CONDITIONING.

(a) Brittleness Temperature[a]

Sample	Brittleness Temperature, deg Cent.	
	Shock-Cooled	Slow-Cooled
717 (type I)[2].....	−45.6	− 6.2
754 (type I).....	−43.7	−12.5
712 (type I).....	−41.9	− 7.3
727 (type I).....	−35.4	− 7.8

(b) Environmental Stress Cracking

Sample	Cracking Agent	Test Temperature	50 per cent Failure Time	
			Shock-cooled	Slow-cooled
P.....	Igepal CO 630	50 C	6.5 min	7 days

[a] ASTM Method D 746 - 55 T, notched test pieces (3).

Acknowledgments:

The authors are grateful to I. M. Cabott, J. H. Claessen, G. G. Litvan, H. Nagata, and E. K. Rowley of Canadian Industries Ltd., and P. E. Campbell, of Phillips Chemical Co., for their interest and helpful suggestions.

References

(1) C. W. Bunn, "Polythene," Edited by A. Renfrew and P. Morgan, Iliffe and Sons Ltd., London, 1957.

(2) P. N. Bestelink and S. Turner, "The Low-Temperature Brittleness Testing of Polyethylene," ASTM Bulletin (TP 156), No. 231, July, 1958, p. 68.

(3) E. A. W. Hoff and S. Turner, "A Study of Low-Temperature Brittleness Testing of Polyethylene," ASTM Bulletin (TP 208), No. 225, Oct. 1957, p. 58.

(4) ASTM Standards on Plastics, Sept., 1958, Appendix I, "Proposed Method of Test for Environmental Stress Cracking of Plastics"; A. M. Birks and A. Rudin, "Measurement of Environmental Stress Cracking of Polyethylene," submitted to ASTM Bulletin.

Extra Durability of Paint on Low-Alloy Steels

By H. R. COPSON and C. P. LARRABEE

Low-Alloy constructional steels are usually selected on the basis of their good mechanical properties. These steels are sometimes designated as high-strength low-alloy steels, as high-tensile strength steels, or as high-tensile strength low-alloy steels. As a group they are characterized by a yield point about one and a half times that of structural carbon steel.

It is quite well known that most of the low-alloy constructional steels also have improved resistance to atmospheric corrosion. The extent of the improvement depends upon the composition, with the copper, nickel, chromium, and phosphorus contents being particularly advantageous. Some of these grades have roughly four to six times the atmospheric corrosion resistance of carbon steels. This pertains to bare uncoated steels which are free to rust.

It is not so well known that this improved corrosion resistance makes paint coatings more durable. Rust will form, of course, at any breaks or discontinuities in the paint coating. Rust also forms to some extent underneath many paint coatings. The accumulating rust tends to break down the paint film. Owing to their better corrosion resistance, much less rust forms on the low-alloy steels than on carbon steels. The smaller amount of rust from the low-alloy steels causes much less damage to paint coatings than does the more voluminous rust from carbon steels. Any rupturing of the paint film permits larger amounts of moisture to contact the steel surfaces, and this accelerates the deterioration.

By prolonging the life of paint, the use of low-alloy steels makes it possible to go much longer before repainting is necessary. The corrosion damage at any rusting areas and the spread of rust from a scratch or other holiday is lessened greatly. The labor in preparation for repainting is reduced. The net result is that the use of low-alloy steels can effect a considerable saving in the cost of labor and materials for maintenance painting.

The present paper attempts to make these points clearer. Published information on the comparative performance of paint coatings on low-alloy steels and on mild steel is reviewed. Some current tests on painted steel specimens are described. Some photographs of painted structures are included. Finally, the beneficial effect of alloying on the atmospheric corrosion behavior of bare unpainted steel is reviewed briefly.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

Literature on Effect of Steel Composition on Durability of Paint

There are numerous comments in the literature to the effect that an improvement in the corrosion resistance of steel has a beneficial effect on the durability of paint coatings (**1, 2**).[1] This shows up in improved adherence of the paint, less pitting of the steel, and greater ease in repainting. Most of this early work was based on comparisons between copper steel and carbon steel.

The most easily accessible data of this kind are those reported by Hudson (**3**), some of which are reproduced in Fig. 1. The paints used were red lead and red oxide paints in a linseed oil medium. The corrosion resistance of the bare metal ranged from that of materials which probably performed like pure iron to something a little better than copper steel. The life to failure of the paint on the most corrosion-resistant steels was about twice that on the least corrosion-resistant iron. This difference was observed in the severe industrial atmosphere at Sheffield.

In a more recent publication (**4**), Hudson stated that steel quality has a bearing on the economics of maintenance painting. When old paint begins to fail, the cost of surface preparation repainting rises slowly at first, and then more steeply, because it becomes necessary to remove paint and clean down to bare metal to an ever-increasing extent. Once the paint has ceased to pro-

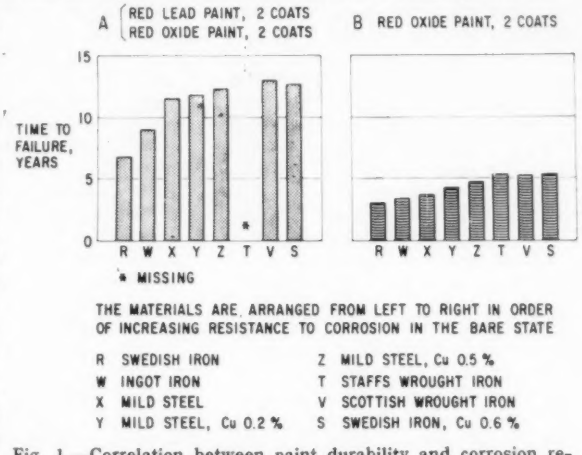
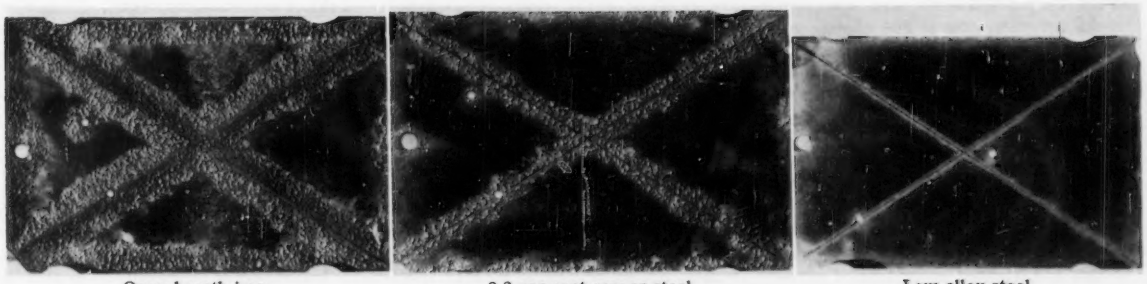

A RED LEAD PAINT, 2 COATS
RED OXIDE PAINT, 2 COATS
B RED OXIDE PAINT, 2 COATS
TIME TO FAILURE, YEARS
15
10
5
0
R W X Y Z T V S
R W X Y Z T V S
* MISSING
THE MATERIALS ARE ARRANGED FROM LEFT TO RIGHT IN ORDER OF INCREASING RESISTANCE TO CORROSION IN THE BARE STATE
R SWEDISH IRON
W INGOT IRON
X MILD STEEL
Y MILD STEEL, Cu 0.2 %
Z MILD STEEL, Cu 0.5 %
T STAFFS WROUGHT IRON
V SCOTTISH WROUGHT IRON
S SWEDISH IRON, Cu 0.6 %

Fig. 1.—Correlation between paint durability and corrosion resistance of basis iron or steel. Exposure at Sheffield in an industrial atmosphere (**3**)

H. R. COPSON is supervisor of the Corrosion Section of the Research Laboratory of The International Nickel Co., Inc., at Bayonne, N. J. He received a B.S. from the University of Massachusetts in 1929 and a Ph.D. in physical chemistry from Yale in 1932. He has been active in corrosion research since 1934, and has published many papers dealing with the atmospheric corrosion of steel. In 1946 he was awarded the ASTM Dudley Medal for a paper entitled, "A Theory of the Mechanism of Rusting of Low Alloy Steels in the Atmosphere."

C. P. LARRABEE is chief research engineer in the Applied Research Laboratory, U. S. Steel Corp., Monroeville, Pa. He received a B.S. in chemical engineering from the Univ. of Maine. For ten years following graduation, he was employed by the Chemistry Division of the National Bureau of Standards. Since then he has been on the staff of the Applied Research Laboratory of U. S. Steel Corp. or its predecessors. Since 1935 he has been concerned with research work on the corrosion of steel products, particularly in the areas of atmosphere and other natural media exposures.



Open-hearth iron | 0.2 per cent copper steel | Low-alloy steel

(*a*) Untreated surfaces.

Open-hearth iron | 0.2 per cent copper steel | Low-alloy steel

(*b*) Surfaces treated with Bonderite.

Fig. 2.—Effect of surface treatment on painted steels exposed 8 months in an atmosphere 80 ft from the ocean at Kure Beach, N. C. (5) Note varying degrees of corrosion extending from original scribe marks.

TABLE I.—COMPOSITION OF STEELS OF TABLE II AND FIG. 2 (REF. 5).

Material	Composition, per cent							
	Carbon	Manganese	Silicon	Sulfur	Phosphorus	Nickel	Copper	Chromium
Open-hearth iron	0.02	0.02	0.002	0.03	0.005	0.05	0.014	Nil
Copper steel	0.05	0.40	0.005	0.02	0.007	Nil	0.21	0.07
Low-alloy steel	0.08	0.30	0.65	0.02	0.09	0.48	0.41	0.85

TABLE II.—EFFECT OF COMPOSITION OF STEEL ON CORROSION UNDER PAINT FILMS 80 FT FROM OCEAN AT KURE BEACH, N. C., FOR 365 DAYS (REF. 5).

Conditions of Exposure	Corrosion Rates					
	Open-Hearth Iron		0.2 per cent Copper Steel		Low-Alloy Steel	
	Mdd[a]	Ipy[b]	Mdd	Ipy	Mdd	Ipy
Bare	212	0.039	28	0.005	13	0.002
Continuous finish over bare steel	55	0.010	5	0.0009	1	0.0002
Scribed finish over bare steel	97	0.018	15	0.003	1	0.0002
Continuous finish over phosphate treated steel	26	0.005	2	0.0004	0.3	<0.0001
Scribed finish over phosphate treated steel	40	0.007	3	0.0006	0.3	<0.0001
Primer only over bare steel	210	0.039	19	0.003	7	0.001
Primer only over phosphate treated steel	133	0.024	13	0.002	6	0.001

[a] Milligrams per square decimeter per day.
[b] Inches per year.

TABLE III.—COMPOSITION OF STEELS IN TABLE IV AND FIGS. 3 THROUGH 6, PER CENT.

	Carbon Steel		Copper Steel		Low-Alloy Steel	
	Cold-Reduced	Hot-Rolled	Cold-Reduced	Hot-Rolled	Cold-Reduced	Hot-Rolled
Carbon	0.03	0.17	0.05	0.16	0.08	0.09
Manganese	0.27	0.40	0.40	0.25	0.30	0.37
Silicon	0.003	0.027	0.003	0.016	0.65	0.60
Sulfur	0.020	0.034	0.016	0.024	0.020	0.022
Phosphorus	0.009	0.013	0.004	0.006	0.09	0.10
Nickel	0.02	0.02	0.07	0.04	0.48	0.46
Copper	0.03	0.04	0.28	0.21	0.41	0.37
Chromium	0.02	0.05	0.03	0.02	0.85	0.92

tect the steel entirely, failure is largely due to the spread of rust beneath the paint film. Consequently, breakdown develops less rapidly on slow-rusting steels than on ordinary steel.

Hudson stated further that the use of a slow-rusting steel should constitute a valuable insurance againt imperfect maintenance. The practical importance of this is probably greater than appears at first, because breakdown of the paint is seldom uniform at all points, the coating failing sooner at some places than at others. The engineer, therefore, has greater latitude in choosing his time for repainting if the spread of the damage at the more vulnerable parts is retarded by the greater intrinsic corrosion resistance of the basis metal. In addition the chance of serious damage to the steel by corrosion is appreciably reduced.

Perhaps the first published investigation using more highly alloyed steel than copper steel was that of LaQue and Boylan (5). They included several low-alloy steels but used the three materials in Table I to summarize their results. These materials are an open-hearth iron, a copper steel, and a high-strength low-alloy steel. All the specimens were painted with a common automobile finish system. This consisted of a pigmented baking alkyd primer with a pigmented baking urea-modified alkyd topcoat which was used with and without a phosphate pretreatment of the metal surfaces. The paint on some of the specimens was scratched through to the bare steel surface (scribe marked) to permit observation of the extent to

which film breakdown and corrosion would progress from a line of exposed steel. The test panels were exposed to a marine atmosphere at Kure Beach, N. C. (80 and 800 ft from the ocean), to an industrial atmosphere at Bayonne, N. J., and to a rural atmosphere at Morenci, Mich.

The appearance of some of these specimens after 8 months at the 80-ft site at Kure Beach is shown in Fig. 2. The weight losses on one set of the specimens at this site, cleaned after 1 yr of exposure, are reproduced in Table II. An inspection of these exhibits shows that the open-hearth iron was the most corroded, both bare and painted. The low-alloy steel was the best in all tests and the copper steel was intermediate. It can be concluded on the basis of these results that there is a very marked advantage in using low-alloy steels.

It is of interest to compare the protection provided to the different steels by the best coating in the tests, namely, the continuously painted phosphated specimens. The open-hearth iron coated in this manner had a corrosion rate eight times lower than bare specimens of the same material, whereas the ratio in the case of the copper steel was 14 and in the case of the low-alloy steel was over 20 and possibly as high as 40. Comparing only the painted specimens it is seen that the low-alloy steel was about five times better than the copper steel and 70 times better than the open-hearth iron.

The 80-ft site at Kure Beach was the most corrosive location in these tests. It produced more corrosion and quicker results than the other sites. Nevertheless the performance of the specimens at these other test sites was in line with the results discussed above, even though the extent of the deterioration was much less, especially at the rural atmosphere at Morenci, Mich.

While the results obtained by LaQue and Boylan are convincing, they were not obtained with the kinds of paint systems that are often used on structural steel parts exposed outdoors. Some data obtained using oil-base paints have been reported by Bermane (6) and by Laubscher and Larrabee (7). These results again show that paint is more durable on low-alloy steels than on copper steel and more durable on copper steel than on mild steel. Nevertheless the reported results are rather sketchy. The exposure tests described below provide more comprehensive data.

Current Tests on Painted Steel Specimens

The compositions of the steels in these tests are given in Table III. The steels are of three types, namely, a carbon steel, a copper steel, and a high-strength low-alloy steel. Specimens, 4 by 6 in. size, were sheared from these steels. The cold-reduced specimens were 0.036 in. thick. These were simply degreased and painted. The hot-rolled specimens were 0.125 in. thick and had mill scale on their surfaces. Before painting they were exposed outdoors to the atmosphere at South Bend, Pa., for 1 month and then wire brushed. Surfaces of typical hot-rolled and weathered specimens, before and after wire brushing, are shown in Fig. 3.

Three paints were used in this investigation: a red lead-linseed oil paint[2] a zinc chromate-alkyd paint[3] and an iron oxide-linseed oil paint[4]. The paint systems consisted of a priming coat of each of these paints, plus a topcoat of the iron oxide-linseed oil paint. All the paints were applied by spraying one side of the specimens to a dry film thickness of approximately 1 mil. The paint films were dried in an oven at about 150 F.

In the spring of 1948, duplicate painted specimens were exposed at three locations. These were an industrial atmosphere at Kearny, N. J., a semirural atmosphere at South Bend, Pa., and a marine atmosphere at Kure Beach, N. C. (800 ft from the ocean). The specimens were mounted on metal racks and were held by porcelain insulators. They were exposed at an angle of 30 deg from the horizontal and faced south. The painted side was skyward.

In Table IV, Section A lists the number of years elapsing until at least 2 per cent of the surface showed breakdown of the paint film. In Table IV, Section B lists the percentage of the surface showing rough rust at 8 yr. Figures 4, 5, and 6 show the appearance of the specimens at Kearny, N. J. at 8 yr.

Inspection of the results show that all paint systems at all locations performed much better on the clean cold-rolled specimens than on the weathered and wire-brushed hot-rolled specimens. This illustrates the value of good surface preparation before painting. A steel surface freed of mill scale and rust by pickling or sandblasting has been stated by other investigators to be greatly superior to an unprepared surface as a base for paint.

At the industrial Kearny location, the paints failed first and the spread of rust was greatest on the carbon steel and least on the low-alloy steel. The copper steel was intermediate. It is to be noted that although some of the paints on the low-alloy steel showed failure by 4.5 yr, these same panels showed a spread of the rusting to only 3 to 10 per cent of the painted area by 8 yr. Some of the

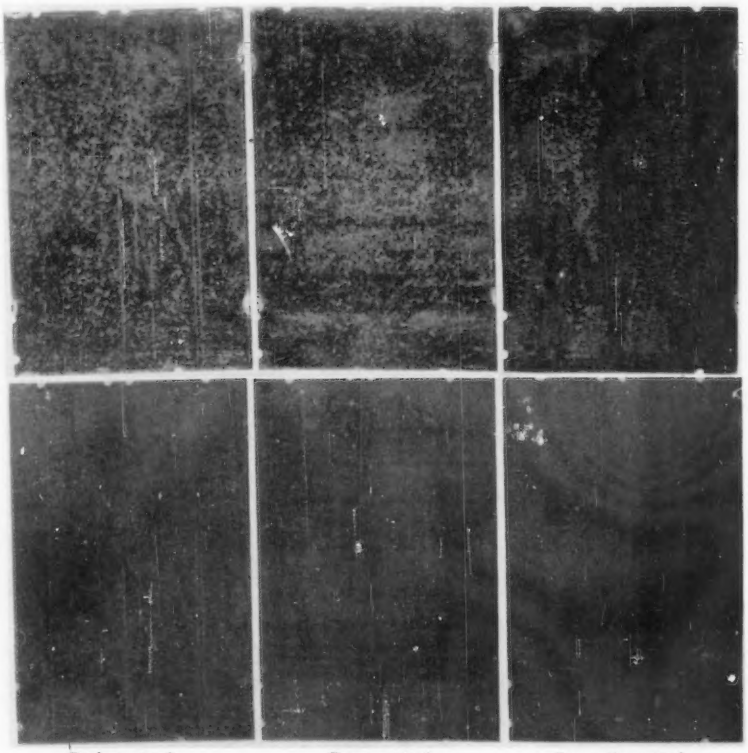


Fig. 3.—Hot-rolled steels before painting. *Top row*—condition after 1 month outdoors at South Bend, Pa. *Bottom row*—condition after wire brushing; darker areas show unremoved mill scale.

[2] Federal Spec. TT-P-86.
[3] A proprietary paint similar to Steel Structures Painting Council Paint 11-55T.
[4] Federal Spec. TT-P-31b.

TABLE IV.—EXPOSURE RESULTS ON PAINTED SPECIMENS.

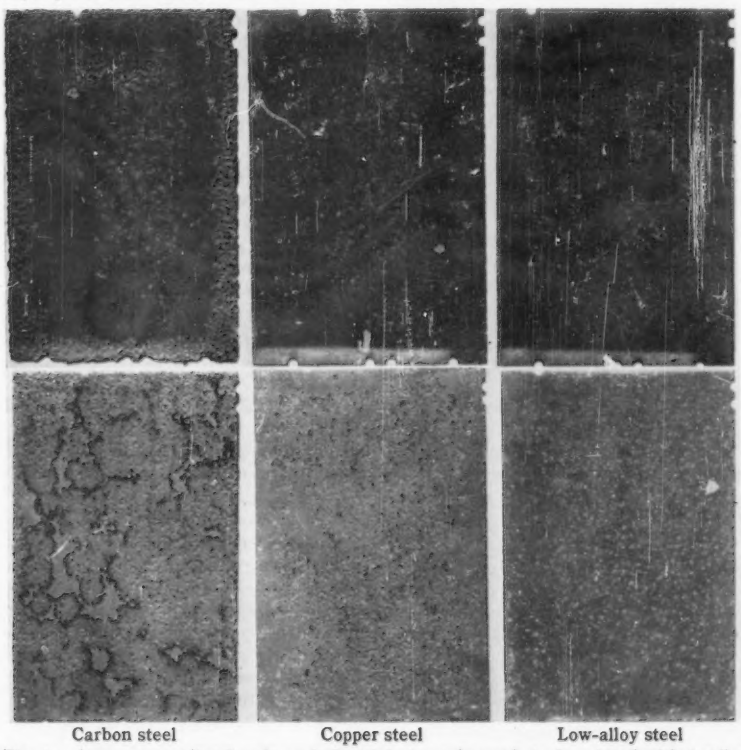
Steel	Condition	Kearny, N. J.			South Bend, Pa.			Kure Beach, N. C. (800-ft Site)[a]		
		Red Lead Primer	Zinc Chromate Primer	Iron Oxide Primer	Red Lead Primer	Zinc Chromate Primer	Iron Oxide Primer	Red Lead Primer	Zinc Chromate Primer	Iron Oxide Primer
A—Years to Paint Failure[b]										
Carbon	Hot-rolled	3.0	2.0	2.5	2.0	3.0	2.0	4.0	[c]	4.0
Copper	Hot-rolled	4.0	4.5	4.0	5.0	8.0	2.0	5.0	[c]	5.0
Low-Alloy	Hot-rolled	4.5	4.5	[c]	[c]	[c]	[c]	6.5	[c]	[c]
Carbon	Cold-rolled	2	2	2	[c]	[c]	[c]	[d]	[c]	[d]
Copper	Cold-rolled	[c]	[c]	[c]	[c]	[c]	[c]	[d]	[c]	[d]
Low-Alloy	Cold-rolled	[c]	[c]	[c]	[c]	[c]	[c]	[d]	[c]	[d]
B—Percentage of Surface Showing Rough Rust After 8 Yr[b]										
Carbon	Hot-rolled	90	50	100	90	25	99	60	Trace	100
Copper	Hot-rolled	50	13	90	10	3	10	30	Trace	50
Low-Alloy	Hot-rolled	10	3	1	Trace	Trace	0	Trace	Trace	Trace
Carbon	Cold-rolled	25	50	98	0.3	0	0.1	0[d]	0	100
Copper	Cold-rolled	Trace	0	Trace	0.1	0	Trace	0[d]	0	80
Low-Alloy	Cold-rolled	0	0	0	Trace	0	0	0[d]	0	0[d]

[a] At Kure Beach cold-rolled carbon steel specimens were perforated at 5 yr and practically destroyed at 8 yr mostly by corrosion from the groundward surface.
[b] A specimen was declared to have failed when the paint film on 2 per cent of the surface, including the area near the edges, had been broken by rust.
[c] Less than 2 per cent visible rust after 8 yr.
[d] Change of color indicated some rust under paint film of carbon steel after 4 yr and the others at 5.5 yr but no breaks in the film were observed.

panels of the other steels were 90 to 100 per cent rusted at 8 yr.

At South Bend, Pa., the performance of the paint systems was similar to that at Kearny, except that in certain cases the attack on the steels was considerably less severe. This was to be expected from the relative corrosiveness of these two atmospheres. At both locations the spreading of the rust was less under the zinc chromate, alkyd paint than under the other two.

At the marine Kure Beach location, the zinc chromate primer did exceptionally well, with only inconsequential breaks in the paint film by 8 yr. In the case of the other paint systems, the differences between the three types of steel were marked. The performance of the paints with the red-lead or iron-oxide primers was considerably better on the low-alloy steel than on the copper steel and very much better than on the carbon steel.



Carbon steel Copper steel Low-alloy steel

Fig. 4.—Appearance after 8 yr in an industrial atmosphere of steels painted with 1 mil of red lead, linseed oil paint, and 1 mil of iron oxide oil paint. *Top row*—cold-rolled specimens. *Bottom row*—wire-brushed, weathered mill-scale surfaces.

These tests show that the life of a paint coating depends on at least four factors: (1) the atmospheric corrosion resistance of the steel itself, (2) the cleanliness of the steel surface to which the paint is applied, (3) the nature of the paint system, and (4) the corrosivity of the particular atmosphere in which the steel is exposed. In all of the atmospheres in which the tests were conducted, paints applied to the low-alloy steel had the longest service life, paints applied to the copper steel had an intermediate life, and paints applied to the carbon steel had the shortest service life.

Photographs of Painted Structures

In addition to having data from precisely controlled exposure tests on small specimens, it is well to know the actual performance of paint coatings on large structures. Two case histories are described below.

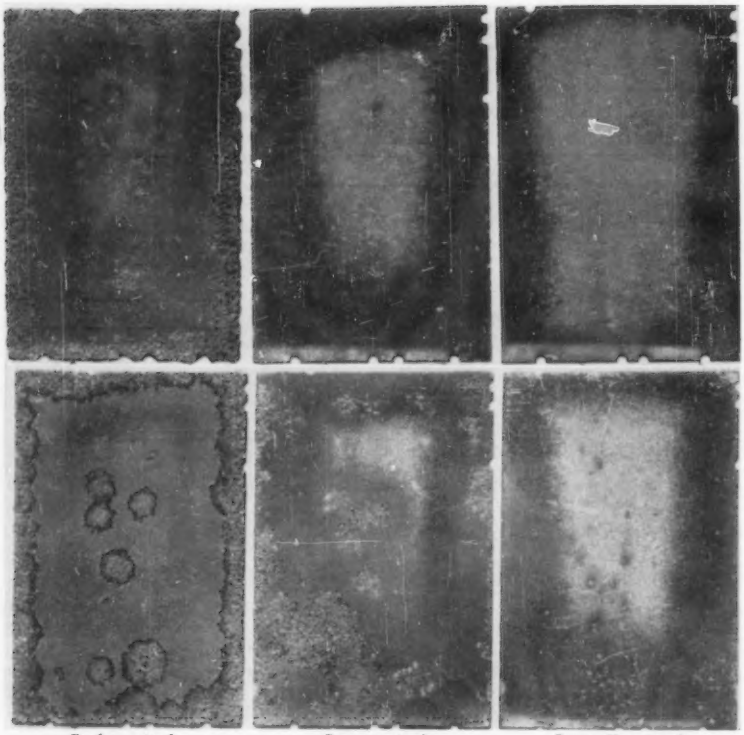
Case 1: Railroad Hopper Cars

A large eastern railroad has made a study of the service life of composite hopper cars. One half of each car was made of a structural copper steel. The other half was made of a high-strength low-alloy steel similar in composition to the low-alloy steels in the tables. The service conditions for the two steels in any one car were equal.

Figure 7 shows the condition of the paint on the steels after 5 yr of service. The paint on the copper steel was missing in large areas. The paint on the low-alloy steel was still giving adequate protection. This result is in accord with what would be expected from the tests described above.

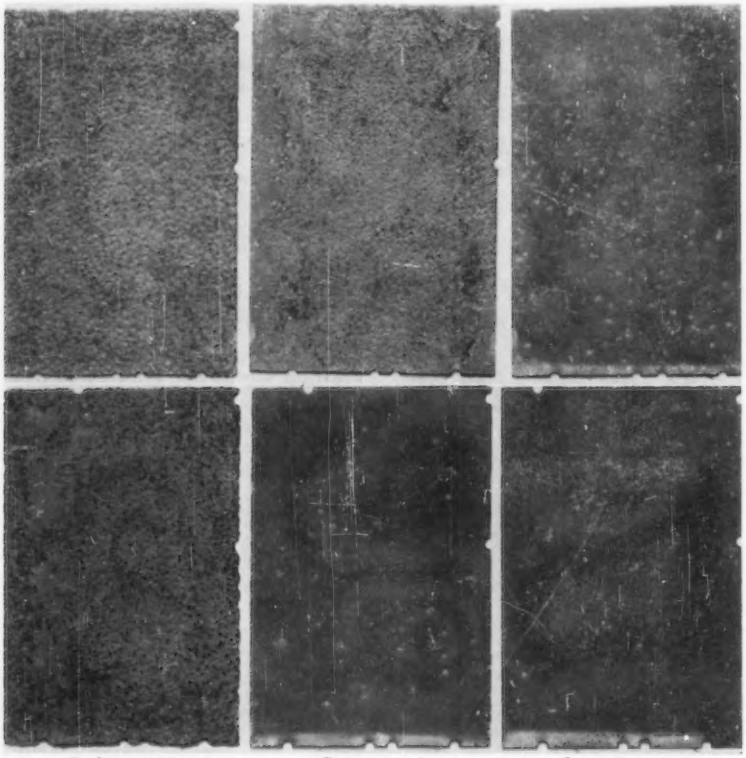
Case 2: State Highway Bridge

In 1949 a railroad bridge was completed over a road in a rural location in Rhode Island. The I-beam spans



Carbon steel Copper steel Low-alloy steel

Fig. 5.—Appearance after 8 yr in an industrial atmosphere of steels painted with 1 mil of zinc chromate, alkyd paint, and 1 mil of iron oxide oil paint. *Top row*—cold-rolled specimens. *Bottom row*—wire-brushed, weathered mill-scale surfaces.



Carbon steel Copper steel Low-alloy steel

Fig. 6.—Appearance after 8 yr in an industrial atmosphere of steels painted with two 1-mil coats of iron oxide oil paint. *Top row*—cold-rolled specimens. *Bottom row*—wire-brushed, weathered mill-scale specimens.

and the riveted outer side plates were of carbon structural steel. The two curb plates extending from the top of the side plates to the floor plates were of a high-strength low-alloy steel similar to that in the tables.

The same paint system was applied to all parts of the bridge. It is thought that a red-lead pigmented primer was employed. It is believed that a red-lead pigmented field coat was also applied after erection, followed by a green chromium oxide pigmented top coat.

Figure 8 shows the condition of the paint in 1959. The carbon steel outer plates were badly rusted and in need of repainting. The paint on the high-strength low-alloy steel curb plates was still in excellent condition. This is a desirable situation, because road ballast covers the lower half of the curb plate, and it would be difficult to repaint in this area.

Atmospheric Corrosion Resistance of Steels

It has been stated that the extra durability of paint on low-alloy steels is due to the improved atmospheric corrosion behavior of such steels. Accordingly it is well to review this subject briefly.

There is a wealth of data on the atmospheric corrosion behavior of bare unpainted steels (**8, 9**). Figure 9 shows some results obtained at a typical industrial location (Bayonne, N. J.). A 6 by 4-in. specimen of open-hearth iron containing 0.01 per cent copper suffered a weight loss of 12 g in 2.75 months. A similar steel specimen of a carbon steel containing 0.05 per cent copper and nominal amounts of manganese, silicon, and phosphorus took 8 months to show the same weight loss. A copper steel took 10 months. One high-strength low-alloy steel took 33 months. The compositions of these materials are given in Table V.

Figure 10 shows similar data obtained at a typical marine location at Kure Beach, N. C. Here the same materials took 4.5, 12.5, 15, and 32.5 months, respectively, to lose 12 g. A weight loss of 12 g is equivalent to an average penetration of about 2 mils from all surfaces.

The reasons for the superior atmospheric corrosion behavior of the low-alloy steels resides in the composition of the steel and in the characteristics of the corrosion products (rusts) of these steels. Rust coatings on the low-alloy steels are darker, thinner, finer textured, less porous, and, therefore, more protective than on plain iron and steels. These differences in the rust coatings are apparent as soon as the first rust starts to form (**10**). Figure 11 shows the appearance of the best and

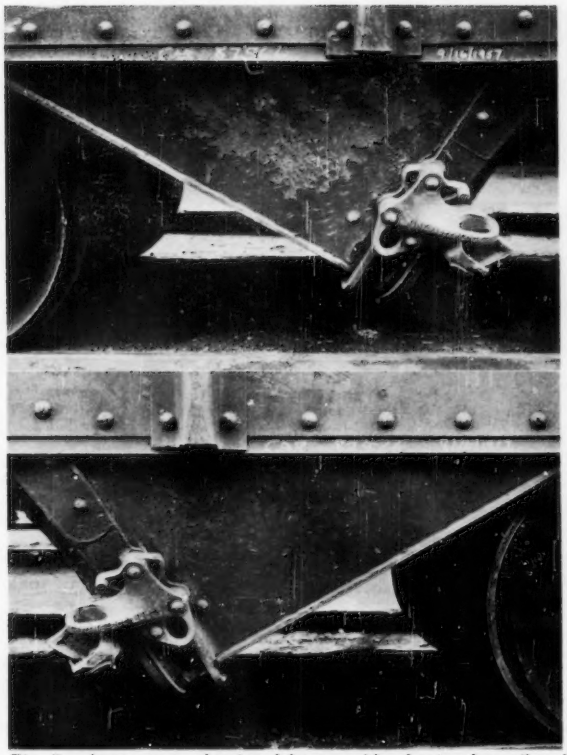


Fig. 7.—Appearance of painted hopper side sheets of a railroad car. *Top*—hopper side sheet of structural copper steel. *Bottom*—hopper side sheet of high-strength low-alloy steel.

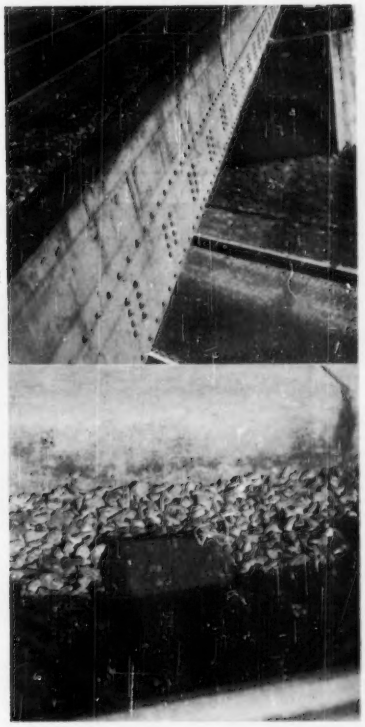


Fig. 8.—Appearance of painted members of railroad bridge. *Top*—outer side plates of carbon steel. *Bottom*—curb plates of high-strength low-alloy steel.

the worst material of Table V after 3.1 yr in the industrial atmosphere. Obviously this superiority in paint life applies equally well to those alloy steels that have atmospheric corrosion resistance about equal to that of the more corrosion-resistant high-strength low-alloy steels. One example of such a grade is AISI 2317 (3.5 per cent nickel).

Of the alloying elements likely to be present, copper, nickel, chromium, and phosphorus are the most effective in

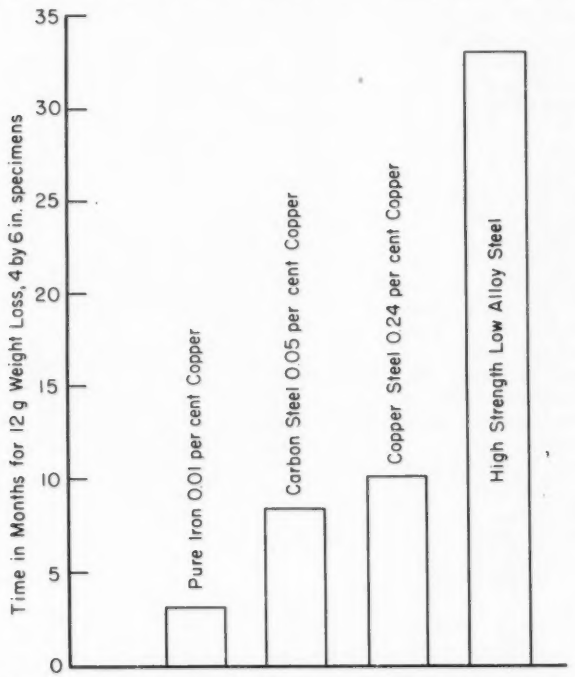


Fig. 9.—Relative durabilities of steels in an industrial atmosphere.

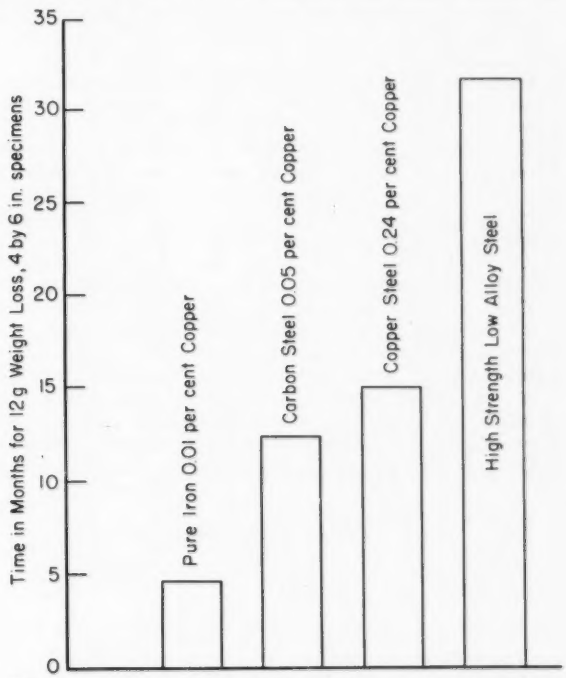
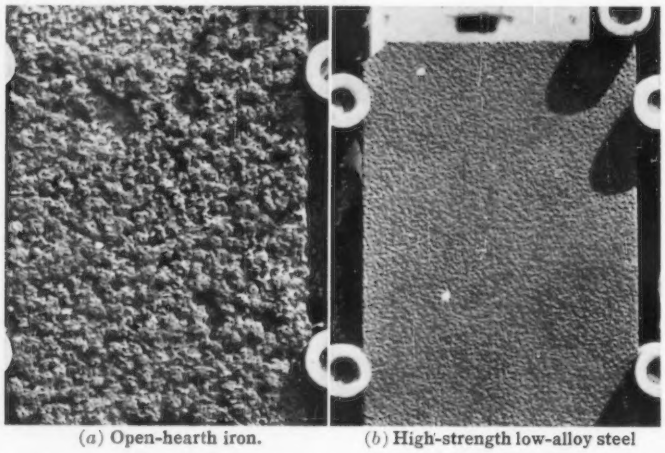


Fig. 10—Relative durabilities of steels in a marine atmosphere.

TABLE V.—COMPOSITION OF STEELS IN FIGS. 9 THROUGH 11.

Material	Composition, per cent							
	Carbon	Manganese	Silicon	Sulfur	Phosphorus	Nickel	Copper	Chromium
Open-hearth iron	0.02	0.02	0.002	0.03	0.005	<0.05	0.014	Nil
Carbon steel	0.04	0.39	0.007	0.02	0.007	0.01	0.05	0.07
Copper steel	0.06	0.32	<0.01	0.02	0.010	<0.05	0.24	Nil
Low-alloy steel	0.08	0.37	0.29	0.03	0.089	0.47	0.39	0.75



(*a*) Open-hearth iron. (*b*) High-strength low-alloy steel

Fig. 11.—Appearance of rust on specimens after 37 months in an industrial atmosphere. Specimens are identified by two drilled holes.

conferring resistance to atmospheric corrosion. The effect of other elements (except sulfur) is relatively minor in the percentages in which they are likely to be present. Sulfur is about the only harmful element, but its effects are offset by the presence of alloying elements. In selecting a high-strength steel, it is worth while to bear in mind the effects of these beneficial alloying elements.

Unalloyed steels corrode at high rates in aggresive atmospheres. The presence of only a few hundredths per cent of copper has a big effect in lowering weight losses. Copper additions over 0.2 per cent are less effective. However in steels alloyed with nickel, copper additions up to 1 per cent are decidedly helpful in increasing atmospheric corrosion resistance.

There is progressive improvement with increasing nickel content, and high-nickel steels are substantially corrosion resistant. Nickel additions produce low initial weight losses, and therefore, can be expected to be particularly effective in painted steels.

There is also progressive improvement with increasing chromium content, and high-chromium steels are quite corrosion resistant. Chromium is especially helpful in decreasing the amount of corrosion occurring during long exposure periods.

Summary

Both field tests and service experience have shown that paint coatings are more durable on high-strength low-alloy steels than on carbon steel or on copper steel. Any rust which forms at breaks or holidays or underneath the paint film is less voluminous on the low-alloy steels. Owing to the smaller volume of rust there is less rupturing of the paint film and, hence, less moisture reaches the steel to promote further corrosion. It is thus evident that the extra durability of the paint is due to the better atmospheric corrosion behavior of the alloy steels. This improved corrosion behavior is associated with the alloy content of the steels, with the copper, nickel, chromium, and phosphorus contents being particularly important.

All this adds up to a considerable saving in the cost of repainting. Where low-alloy steels are used it is possible to go much longer before repainting. In general there will be less rusting so that the labor involved in preparation for repainting is reduced. An added benefit is that there will be less damage to the steel at any places where rusting develops.

References

(1) F. N. Spelier, "Corrosion Causes and Prevention," McGraw-Hill Book Co., New York, p. 324 (1951).

(2) U. R. Evans, "Metallic Corrosion, Passivity and Protection," Longmans, Green & Co., New York, p. 188 (1948).

(3) F. Fancutt and J. C. Hudson, "The Work of the Protective Coatings (Corrosion) Subcommittee," *Corrosion*, Nat. Assn. Corrosion Engrs., Vol. 8, 1952, p. 366.

(4) J. C. Hudson, "Protection of Steel by Painting Against Atmospheric Corrosion," *Schweizer Archiv für angewnadte Wissenschaft und Technik*, Vol. 2, 1958, p. 24.

(5) F. L. LaQue and J. A. Boylan, "Effect of Composition of Steel on the Performance of Organic Coatings in Atmospheric Exposure," *Corrosion*, Nat. Assn. Corrosion Engrs., Vol. 9, 1953, p. 237.

(6) D. Bermane, Results of Research of the Belgian Corrosion (Protection) Committee, Official Digest Federation Paint and Varnish Production Clubs, Vol. 27, No. 371, Dec., 1955, p. 1027.

(7) A. N. Laubscher and C. P. Larrabee, "Protecting Sheet-Steel Products," *Paint and Varnish Production*, Aug., 1957.

(8) C. P. Larrabee, "Corrosion Resistance of High-Strength Low-Alloy Steels as Influenced by Composition and Environment," *Corrosion*, Nat. Assn. Corrosion Engrs., Vol. 9, 1953, p. 259.

(9) H. R. Copson, "Atmospheric Corrosion of Low-Alloy Steels," *Proceedings*, Am. Soc. Testing Mats., Vol. 52, 1952, p. 1005.

(10) F. L. LaQue, "Corrosion Testing," "*Proceedings*, Am. Soc. Testing Mats., Vol. 51, 1951, p. 495.

Demulsibility Test for High-Viscosity Oils

A Report of Technical Committee C on Turbine Oils of ASTM Committee D-2 on Petroleum Products and Lubricants

By E. W. BRENNAN[1]

It has been brought to the attention of Technical Committee C of ASTM Committee D-2 on Petroleum Products and Lubricants that the common demulsibility tests such as ASTM Method D 1401[2] and the Herschel method are unsatisfactory for evaluating circulating oils with viscosities above 500 SUS (Saybolt Universal Seconds) at 100 F, and that a need exists for a method to evaluate oils with viscosities up to 3000 SUS at 100 F.

The new Dynamic Demulsibility Test, which was developed for evaluating compounded paper-machine oils in the viscosity range of 600 to 1000 SUS at 100 F, was proposed for cooperative study to determine its possible application. Figure 1 illustrates this equipment,[3] and the flow diagram of Fig. 2 shows that it is a small-scale simulation of service conditions.

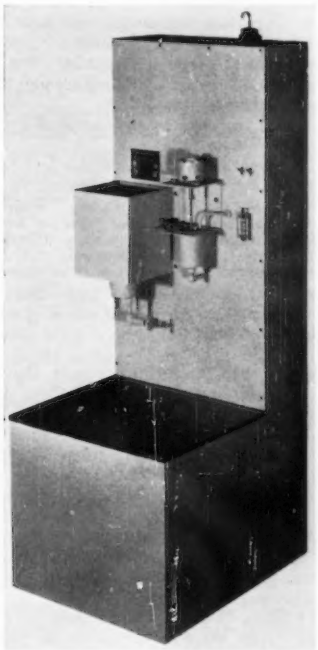


Fig. 1.—Dynamic demulsibility apparatus, Labline Inc., Chicago, Ill.

In the Dynamic Demulsibility Test, oil flows from the top of the reservoir into the mixing chamber where it meets and is stirred together with a stream of water. The oil-water mixture is pumped from the mixing chamber to a point near the bottom of the reservoir, where the average residence time of the oil is 37½ min before it flows out of the top for additional water contamination. During its stay in the reservoir, the oil is heated, if necessary, to hold it at the selected test temperature; the water tends to settle to the bottom where an automatic valve opens intermittently to drain off excess liquid. This is necessary to compensate for the water addition. At the end of the 6-hr test period, samples from the top and bottom of the reservoir are examined for water content.

The detailed procedure is presented in the Appendix. The selection of test temperature depends upon oil viscosity and service conditions. Tables I, II, and III present data obtained in the author's laboratory.

Table I presents demulsibility data obtained by the Steam Emulsion Number Method, Herschel Method, and the Dynamic Demulsibility Test, and from service records in kraft paper mills. Correlation with field performance is apparently quite good for the dynamic test and relatively poor or nonexistent for the other two methods.

Table II illustrates the effect of additive types and test temperature. All oils were compounded to approximately the same level of rust and oxidation inhibition and detergency. Obviously, the demulsibility characteristics varied, as shown by the Dynamic Demulsibility Test. With the exception of oil D, the demulsibilities are poorer at the lower temperature.

The repeatability data shown in Table III are felt to be satisfactory for a test of this type.

In consideration of its usefulness for evaluating paper-machine oils, the Dynamic Demulsibility Test was selected for study by Section IV of Technical Committee C, and a study group was established.

Three viscosities were selected: 500 1000, and 2000 SUS at 100 F. One nonadditive oil and one rust and oxidation inhibited (R and O) oil was chosen for each viscosity. The test temperature in all cases was 180 F.

Cooperative test data for the nonadditive oils are shown in Table IV, while those for the inhibited oils are presented in Table V. Repeatability was quite satisfactory and, based on the limited amount of evidence presented,

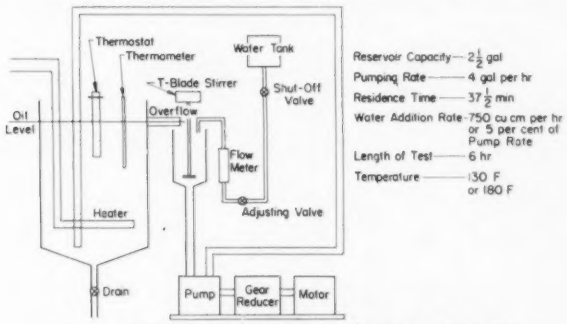


Fig. 2.—Dynamic demulsibility apparatus flow diagram.

TABLE I.—COMMERCIAL PAPER MACHINE OILS, VISCOSITY 500 TO 700 SSU AT 100 F.

Oil	Steam Emulsion No.	Herschel Demulsibility at 180 F	Dynamic Demulsibility at 180 F		Demulsibility as Observed in Paper Machine
			Water at Top, per cent	Water at Bottom, per cent	
1...	1200	750	4	70	Fair
2...	1200+	<50	4	50	Poor
3...	1020	<50	3.6	77	Fair to Good

[1] Project supervisor, The Pure Oil Co., Research Center, Crystal Lake, Ill.

[2] ASTM Tentative Method of Test for Emulsion Characteristics of Steam-Turbine Oils, 1958 Book of ASTM Standards, Part 7, p. 795.

[3] Labline, Chicago, Ill., Catalog No. 4590.

TABLE II.—DYNAMIC DEMULSIBILITY, EXPERIMENTAL PAPER-MACHINE OILS, VISCOSITY 500 TO 700 SUS AT 100 F.

Oil	Water Content, per cent			
	At Top		At Bottom	
	130 F	180 F	130 F	180 F
A	16	4.0	75	98
B	14	7.0	100	100
C	12	4.0	90	99
D	6	5.6	100	100

TABLE III.—DYNAMIC DEMULSIBILITY DATA AT 130 F, PAPER-MACHINE OILS, VISCOSITY 500 TO 700 SUS AT 100 F.

Water Content, per cent			
Oil A		Oil B	
At Top	At Bottom	At Top	At Bottom
11.5	81	10.0	96
13.5	82	10.0	96
14.0	80	9.5	97
12.0	82	10.5	94
13.0	82	12.0	96
12.8 average	81.4 average	10.4 average	95.8 average
2.5 range	2 range	3.5 range	3 range

TABLE IV.—DYNAMIC DEMULSIBILITY DATA (WATER CONTENT, PER CENT) 180 F, NONADDITIVE OILS.

	Oil No. 57-1, Viscosity 500 SSU at 100 F		Oil No. 57-2, Viscosity 1000 SSU at 100 F		Oil No. 58-3, Viscosity 2000 SSU at 100 F	
	At Top	At Bottom	At Top	At Bottom	At Top	At Bottom
Laboratory A	0.5 0.5	100 100	1.5 1.5	90 90	... ...	... ...
Laboratory B	0.8 0.6	97.5 100	2.2 2.2	90 90	7.0 6.7	78 82
Laboratory C	...	...	...	...	2.8 2.6	60 40
Laboratory D	0.7	98	2.4	90	9.0	70
Laboratory E	0.65 0.60	99 100	2.7 2.8	92 92	8.8 8.7	82 84
Laboratory F	...	...	...	...	4.8 3.2	66 53

TABLE V.—DYNAMIC DEMULSIBILITY DATA (WATER CONTENT, PER CENT), 180 F, R AND O OILS.

	Oil No. 58-1, Viscosity 500 SUS at 100 F		Oil No. 58-2, Viscosity 1000 SUS at 100 F		Oil No. 57-3, Viscosity 2000 SUS at 100 F	
	At Top	At Bottom	At Top	At Bottom	At Top	At Bottom
Laboratory A	...	...	...	...	9.0 8.8	75 75
Laboratory B	1.8 2.4	98 99	4.8 5.2	100 99	7.0 8.0	77 76
Laboratory C	1.8 1.8	100 85	4.6 4.4	100 98	...	...
Laboratory D	5.0	94	8.0	85	10	86
Laboratory E	2.3 2.5	99.5 99.0	5.9 5.6	99.5 99.5	...	...
Laboratory F	1.1 0.9	99 99	3.8 3.0	100 100	...	...

TABLE VI.—EMULSION VALUES, ASTM METHOD D 1401, 180 F.

Laboratory	Oil 57-1	Oil 57-2	Oil 57-3	Oil 58-1	Oil 58-2	Oil 58-3
M	40-40-0 (5)	40-37-3 (43)	26-6-48 (60)	...	...	...
N	40-40-0 (5)	40-40-0 (15)	40-37-3 (60)	40-40-0 (10)	40-40-0 (60)	35-35-10 (60)
O	...	...	...	40-40-0 (7)	40-40-0 (25)	40-16-24 (60)

reproducibility between certain laboratories was acceptable.

Table VI contains data obtained by the ASTM Method D 1401 with the six oils for comparative purposes. It should be noted that this method has official application to oils having viscosities no greater than 500 SUS at 100 F, and at only the specified temperature of 130 F. These data show the test method to be of little value for high-viscosity oils.

Section IV is planning further cooperative work with the Dynamic Demulsibility Test to prove further its apparent usefulness.

APPENDIX

Dynamic Demulsibility Test Procedure

1. Fill the mixing chamber with test oil and start the pump to flush the lines. Pump all the oil from the mixing chamber into the reservoir. Shut off the pump and drain the reservoir.

2. Clean the reservoir with solvent—use a brush if necessary but be careful to allow no loose bristles to get into the solenoid valve. Rubber solvent is satisfactory.

3. Drain and wipe out excess solvent.

4. Fill the reservoir to the overflow pipe and the mixing chamber to about half full with test oil. Put a large container under the solenoid valve to catch discharged liquid.

5. Turn the heater on and insert a thermometer into the reservoir. Adjust the thermometer so that it is in a vertical position in front of the overflow pipe and immersed about 3 in.

6. Adjust the heat control for the desired temperature.

7. When the oil reaches the test temperature start the pump and mixer.

NOTE.—When the pump switch is turned on the solenoid valve may open for a few seconds until the relay reaches operating temperature. It may be necessary to hold a finger over the valve outlet until it closes.

8. Start the water flow and adjust to 12 ml per min (5 per cent of oil circulation rate). Start timer.

9. When the test has run about 20 min less than the full test period, that is, 5 hr 40 min, put a 100-ml centrifuge tube under the solenoid valve. Allow the machine to operate automatically until the tube in nearly full, then use the manual solenoid control switch to fill the tube to the 100 ml mark. Repeat with the second centrifuge tube.

10. After the full test period, that is, 6 hr, draw off a 50-ml sample from the overflow pipe into each of two 100-ml centrifuge tubes.

11. Shut off the heat and water.

12. Drain the reservoir while the pump is running so that the mixing chamber will be emptied.

13. Dilute the top oil samples with naphtha to the 100-ml mark in the tubes and centrifuge all samples at 1500 rpm for 15 min. Record per cent water at top and bottom. If an emulsion persists in the centrifuge tube it is measured as water.

A Method for Determining the Demulsibility of Lubricating Oils

By PAUL D. METZGER[1]

THE lubrication engineers of the Wheeling Steel Corp., as well as many others in the lubrication field, realizing the shortcomings of the insisting demulsibility tests for measuring the ability of an oil to separate from a mixture of oil and water, expressed a need for a test that would classify oils in a definite order as to their water separating properties.

This ability of an oil to separate from water will be referred to here as the "demulsibility" of an oil. Any water entering an oil system should separate as the mixture reaches the sump tank. The water should fall to the bottom of the tank by gravity, leaving relatively dry oil to be returned to the bearings. This water should be relatively free of emulsion—either oil-in-water or water-in-oil type emulsion.

The first problem encountered in developing a demulsibility test was to produce a mixture of water in oil that would be comparable to that produced in a steel-mill oil system. Several types of pumps were investigated and rejected for various reasons. A standard food blender was tried, and although the resulting mixture of water in oil produced with this equipment was much the same in appearance as the mixture found in mill systems, the geometry of the receptacle was objectionable. A discussion of this problem with a visitor from a research laboratory of one of the major oil producers led to the development of the "draft tube mixer" (Fig. 1) used in this test.

A variable-speed motor capable of developing a speed of 4000 rpm while mixing the water in the oil was used to drive the "draft tube mixer," the direction of rotation being such that the fluid enters the top port (located slightly above the top propeller) and is forced down through the bottom of the "draft tube." A standard 500-ml graduated cylinder was chosen as the container for mixing and studying the separating of the water from the oil. The problem in reading the small increments of water or emulsion separating from the oil-water mixture led, however, to the development of the special separatory type funnel (Fig. 2) now in use.

We are interested in the percentage of water remaining in the oil at or near the surface of the oil as well as the volume of water or emulsion that

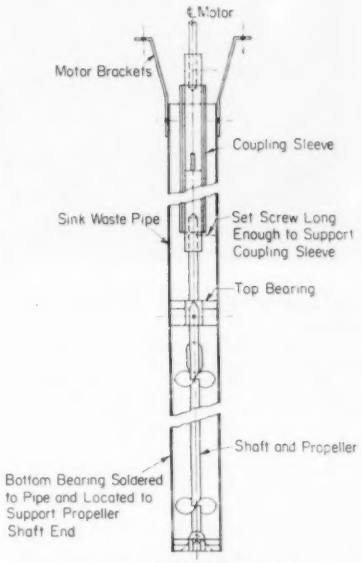

Motor
Motor Brackets
Coupling Sleeve
Sink Waste Pipe
Set Screw Long Enough to Support Coupling Sleeve
Top Bearing
Shaft and Propeller
Bottom Bearing Soldered to Pipe and Located to Support Propeller Shaft End

Fig. 1.—Draft tube mixer.

separates from the oil-water mixture. A 10-ml volumetric pipet is used to withdraw samples of oil from the funnel for the determination of water by ASTM Method D 96.[2] A study of the depth at which this sample should be taken led to the decision that the location should be $2 \pm \frac{1}{2}$ in. below the surface of the oil and at the center of the funnel. Figure 3 shows a centering and measuring device developed for the convenience of the operator.

Any suitable constant-temperature bath capable of maintaining the temperature of the oil-water mixture at 180 F completes the necessary apparatus for determining the demulsibility characteristics of lubricating oils by this method.

As may be expected, several changes in this test procedure have been made since its original conception. The settling time and the temperature of the test were chosen to correspond with mill practice, while the percentage of water in the water-oil mixture and the stirrer speed were chosen arbitrarily. The further use of this test may bring about further changes in the test procedure, but at this time the procedure is as follows:

Test Proceedure

Measure the oil under test, at room temperature, directly into the separatory funnel to a volume of 405 ml. Then place the separatory funnel and oil into the constant temperature bath and bring to a temperature of 180 F.

Add 45 ml of distilled water, measured at room temperature, to the oil and immerse the stirrer to a depth of 1 in. from the bottom of the funnel. Be sure that the stirrer tube is not in contact with the funnel while the stirrer is operating.

Slowly bring the stirrer motor to a speed or 4500 ± 500 rpm, within 25 to 30 sec, and operate for a total of 5 min. Then withdraw stirring tube from the oil-water mixture, but not entirely out of the separatory funnel. Allow the stirrer to drain for 5 min and then remove from the separatory funnel.

After an additional 5 min have elapsed (10 min after stirring), using a 10 ml pipet, withdraw a 10-ml sample from the center of the funnel, 2 in. below the surface of the mixture.

Discharge the contents of the pipet into a centrifuge tube, allowing 1 hr discharge time. Determine the water content of the sample by ASTM Method D 96, and record the results. Record water in amounts less than 0.5 per cent as "trace."

After an additional 4 hr 50 min, that is, 5 hr after stirring has stopped, take another 10-ml sample with a 10-ml pipet from the center, 2 in. below the surface of the mixture. Drain this sampling pipet, centrifuge the sample, and record the results as previously described.

Immediately after taking the 10-ml sample, remove the separatory funnel from the bath and draw off any free

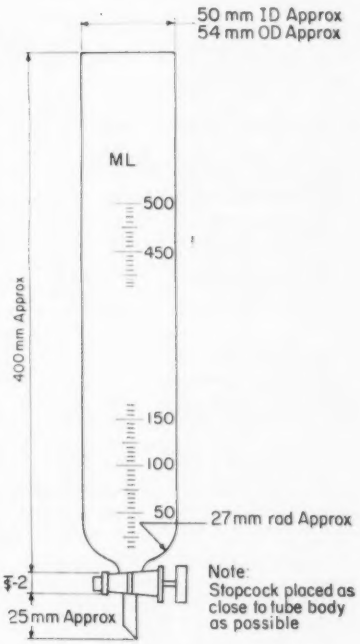


Fig. 2.—Special separatory funnel.

[1] Research engineer, Wheeling Steel Corp., Research Laboratory, Wheeling, W. Va.

[2] ASTM Tentative Method of Test for Water and Sediment by Means of Centrifuge, 1958 Book of ASTM Standards, Part 6, p. 279; Part 7, p. 46.

water that has separated from the mixture. Allow this water to cool to room temperature, measure the volume and record as "Milliliters Free Water After 5 Hours' Settling."

Allow the separatory funnel to cool and remain at room temperature for 19 hr, that is, a total of 24 hr after stirring stopped. After this 19-hr settling period, drain from the funnel any free water or emulsion layer that has separated from the mixture, measure, and record in milliliters. The determining factors for the demulsibility characteristics of the oil are:

1. The water content of the oil after 5 hr settling time at 180 F.
2. The total amount of "Free Water" removed after 24 hr settling time (5 hr at 180 F, plus 19 hr at room temperature).
3. The quantity of emulsion drained from the funnel.

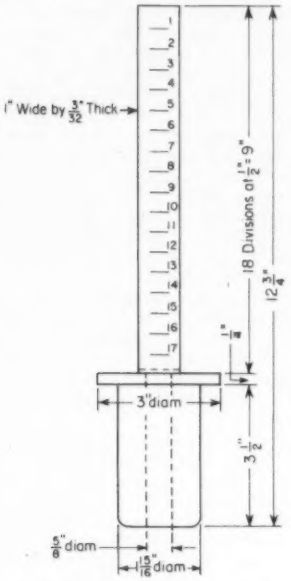


Fig. 3.—Sampling gage and centering device.

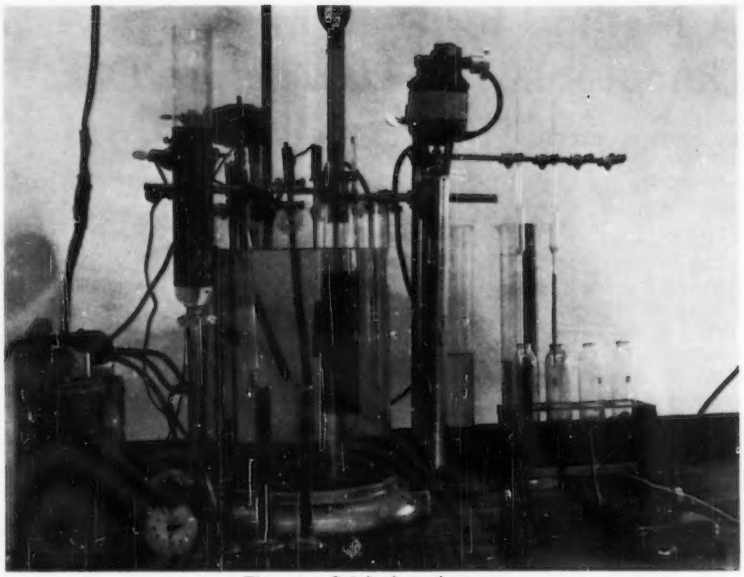


Fig. 4.—Original equipment.

The development and introduction of this test method to the trade resulted in the follwing major questions:

1. Why is such a test necessary?
2. Can the results be repeated?
3. Is this test effective over a wide range of oil viscosities?
4. Can the test be reproduced by other laboratories?
5. Does the test predict how the oil will react in a mill system?

These questions have, of course, been answered to our own satisfaction. The problem now is to convince others of the necessity and usefulness of the test.

TABLE I.—DEMULSIBILITY DATA ON ASTM OILS.

Settling Time After Stirring	Original Equipment						"New" Equipment					
	Operator No. 1 No. of Tests—4			Operator No. 2 No. of Tests—4			Average of Operators No. 1 and 2 No. of Tests—8			Operator No. 1 No. of Tests—6		
	Average	High	Low	Average	High	Low	Average	High	Low	Average	High	Low
ASTM Oil 58-1, Viscosity 505 SSU at 100 F												
10 Min												
Water in oil, per cent	5.3	6.0	4.0	5.2	5.5	5.0	5.3	6.0	4.0	6.9	8.0	4.5
5 Hr												
Water in oil, per cent	Trace	Trace	0	0	0	0	Trace	Trace	0	0	0	0
Total free water, ml	39.3	40.0	39.0	37.7	37.8	37.6	38.7	40.0	37.6	37.3	39.0	35.5
24 Hr												
Total free water, ml	40.1	41.0	39.5	37.7	38.0	37.0	38.9	41.0	37.0	39.4	40.0	39.0
Emulsion, ml	Trace	Trace	Trace	0	0	0	Trace	Trace	0	0	0	0
ASTM Oil 58-2, Viscosity 1015 SSU at 100 F												
10 Min												
Water in oil, per cent	10.5	11.0	10.0	8.8	9.0	8.0	9.6	11.0	8.0	9.7	11.0	8.0
5 Hr												
Water in oil, per cent	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	0
Total free water, ml	37.2	38.2	37.0	36.5	37.0	36.0	37.1	38.2	36.0	37.2	38.0	37.0
24 Hr												
Total free water, ml	37.8	39.0	37.0	36.5	37.0	36.0	37.1	39.0	36.6	37.7	38.5	37.3
Emulsion, ml	0	0	0	0	0	0	0	0	0	0	0	0
ASTM Oil 58-3, Viscosity 2155 SSU at 100 F												
10 Min												
Water in oil, per cent	8.0	9.0	7.0	9.8	10.0	9.0	8.9	10.0	7.0	8.2	9.0	8.0
5 Hr												
Water in oil, per cent	2.4	3.0	2.5	4.4	6.0	3.0	3.6	6.0	2.5	3.8	4.0	3.5
Total free water, ml	4.2	7.8	0	9.2	9.4	9.2	5.8	9.0	0	9.6	10.9	8.8
24 Hr												
Total free water, ml	8.4	11.5	2.0	11.0	14.0	9.0	8.7	14.0	2.0	10.5	12.6	9.0
Emulsion, ml	19.1	25.5	11.5	8.0	9.0	7.0	13.6	25.5	7.0	5.7	7.0	4.0

It is generally conceded that the "steam emulsion number" test is not a satisfactory test for demulsibility of oils, and that ASTM Method D 1401[3] is not well suited for more viscous oils (over 500 SSU (Saybolt Universal Seconds) at 100 F). Since no other method had been suggested at this time, it was necessary to develop a test that could be used to classify oils, over a wide range of viscosity, as to their demulsibility characteristics.

The data in Table I developed in working with three oils received under code Nos. ASTM oil 58-1, 58-2, and 58-3 is offered as proof that the results of the test can be repeated by the same operator, by two different operators, and on two different pieces of equipment.

The original equipment (Fig. 4) was built and assembled by the Wheeling Steel Research Laboratory; and the "new" equipment (Fig. 5) which was built by a laboratory equipment supplier, is the equipment now in use at the Research Laboratory.

The data in Table I show that both the original and "new" equipment, as well as different operators, classify the three oils in the same order. That is oil 58-1 shows the best demulsibility characteristics; oil 58-2 is second best, but not far behind 58-1; and oil 58-3 shows the poorest demulsibility characteristics.

The question of whether the test is effective over a wide range of oil viscosities can best be answered by noting the viscosities of the three oils in Table I. This, we believe, covers a wide range of oil viscosities.

Sufficient data have not been developed by two of the three laboratories presently working with this test to be able to predict the reproducibility of the test between laboratories. We do feel, however, that the data in Table I comparing the original and "new" equipment indicate that the test can be expected to show good reproducibility between laboratories.

The test is also too new to provide sufficient data to prove conclusively that an oil having poor demulsibility characteristics as demonstrated by this test will have poor demulsibility characteristics in a mill circulating oil system. In support of the test, however, are data (Table II) obtained from tests on an oil in service in one of our plants. Code No. OL-238 represents a "branded" straight mineral oil produced by a major oil company and having a refinery Herschel demulsibility of 1620; Code No. OL-239 represents this same brand of oil from an operating tank of a circulating system in service; and Code No. OL-240 represents this same brand of oil from the idle or standby tank of the same circulating system. From the data it can be seen that all the samples of this "branded" oil (one "new" and two "used" samples) show poor demulsibility characteristics. The plant lubrication engineer verified our laboratory findings by complaining of having trouble in separating water from this oil.

[3] ASTM Tentative Method of Test for Emulsing Characteristics of Steam-Turbine Oils, 1958 Book of ASTM Standards, Part 7, p. 795.

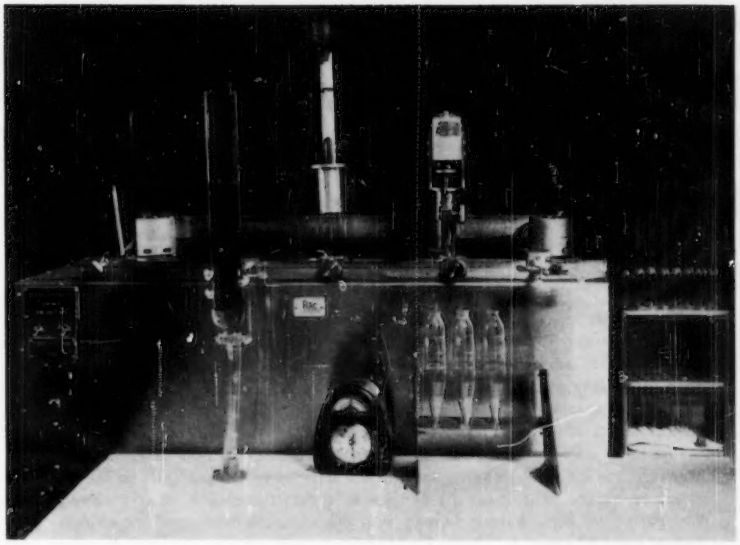


Fig. 5.—"New" equipment.

TABLE II.—DEMULSIBILITY DATA ON A NEW OIL AND THE SAME OIL IN SERVICE.

Settling Time After Stirring	Code No. OL-238 New Oil			Code No. OL-239 Operating Tank Oil			Code No. OL-240 Idle Tank Oil		
	Average	High	Low	Average	High	Low	Average	High	Low
10 Min Water in oil, per cent	7.9	8.0	7.3	14.1	14.3	14.0	11.8	12.0	11.0
5 Hr Water in oil, per cent	2.9	5.3	2.0	12.8	13.0	12.0	Trace	Trace	Trace
24 Hr Total free water, ml	8.9	10.6	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Emulsion, ml	17.4	19.0	16.2	384	390	380	254	261	237

An additional case that cannot be supported by data is as follows: A "branded" oil having a refinery Herschel demulsibility of 1620, produced by another major oil company, was submitted to the Wheeling Steel Research Laboratory for evaluation. The demulsibility test presented here disqualified this oil on the grounds that it had poor demulsibility characteristics. At the same time, a competitive steel-producing company purchased a quantity of this oil for one of its circulating systems, and shortly thereafter we received a report that this oil was proving troublesome in that it would not shed water readily.

It is conceded that the above is not conclusive evidence, and that many other variables can affect demulsibility of the oil in a mill system, but we feel that this method for determining the demulsibility characteristics of an oil will predict the demulsibility of the oil when placed in a system as well as any other laboratory demulsibility test available.

The personnel of the Wheeling Steel Research Laboratory are satisfied that this method for determining the demulsibility characteristics of lubricating oil will prove to be an outstanding research tool for the oil producer to use in developing circulating oils that may, or will, be contaminated with water; as a guide that will direct the purchases of new oils; and for the evaluation of oils in service. The method is easy to follow and not time consuming, requiring little immediate attention or special talent for manipulation. The test equipment is not too complicated or expensive to build. It is available from at least one laboratory equipment supplier at a cost that is not prohibitive.

Thus, far, straight mineral and "R and O" (rust and oxidation inhibited) oils have been investigated, and the "E. P." (extreme pressure) type oils are now scheduled for study with this method.

Torsion Pendulum Method for Determining Crystallinity and Void Content Of Tetrafluoroethylene Resins*

By N. G. McCRUM

The properties of articles fabricated from "Teflon"[1] TFE- fluorocarbon resins are largely determined by the crystallinity developed during fabrication. As with other semicrystalline plastics, the density of the article increases with increasing crystallinity. The unusual nature of TFE fabrication processes leads sometimes to the formation of small voids which affect the properties of the final article including the apparent density. In order to control crystallinity and void content during fabrication, a method is required to measure the inherent density, that is, the density of the material in the absence of voids. The inherent density is a direct measure of crystallinity. Comparison of the inherent density with the apparent density allows calculation of the void content. It has been found that the torsion modulus of specimens made from TFE resins is determined by the crystallinity and is independent of the void content.

In this paper, a torsion pendulum is described for use in determination of the torsion modulus. This measurement provides a basis for determination of both crystallinity and void content in articles fabricated from TFE resins.

THE quality of articles fabricated from "Teflon" TFE-fluorocarbon resins is largely determined by the crystallinity and void content (1).[2] Articles are fabricated by preforming the molding powder followed by sintering, a technique similar to that used in power metallurgy. Conventional techniques used for thermoplastic materials cannot be used with TFE resins because of their extremely high-melt viscosity. Voids are formed in regions where the resin particles do not fuse together completely during sintering. The total volume of voids formed in commercial fabrication varies between 0 and 2 per cent and their size from submicroscopic to somewhat smaller than that of the TFE resin particle.[3] For a particular TFE resin, the void content of the fabricated article is determined by the method of cold pressing and sintering, whereas the crystallinity depends upon the rate of cooling from the molten to the solid state. The properties of articles molded from TFE resins which are governed by crystallinity and void content are therefore largely controlled by the fabricator. Since these properties include stiffness, flex life, permeability, tensile properties, and dielectric strength, it is obvious that the determination of crystallinity and void content is important in quality control.

A measurement of the density of semicrystalline polymers is usually the simplest method of determining the crystallinity. However, the presence of voids vitiates this method, and consequently other methods must be employed to measure the crystallinity of specimens made from TFE resins. X-ray and infrared techniques (2) are not suitable for quality control both on account of the complexity of the measuring technique and the high cost of the equipment. We were therefore led to consider simpler methods which could be used to measure crystallinity.

Principle of the Method

In Fig. 1 is shown a plot of the variation with temperature of the dynamic torsion modulus G of four specimens made from TFE resins of crystallinity 48 per cent, 64 per cent, 76 per cent and 92 per cent as determined by the infrared method. Below −130 C the torsion modulus is insensitive to crystallinity. However, above an amorphous transition between −130 C and −60 C, the modulus at a given temperature increases with increasing crystallinity. The crystallinity may thus be determined by measurement of the modulus at room temperature and the correlation between crystallinity and torsion modulus shown in Fig. 2.

Since specimens made from TFE resins contain voids, we recognize two densities, the inherent density d_0, and the apparent density, d. The inherent density of the polymer, d_0, excludes the voids and depends only on the crystallinity. The relation between d_0 and crystallinity is known. The apparent density depends on both crystallinity and void content, principally the latter. The void content, v, may be defined as,

$$v = \frac{d_0 - d}{d_0} \times 100 \quad \ldots\ldots (1)$$

The determination of crystallinity and void content thus reduces to measuring d_0 and d by independent methods. It has been found that the torsion modulus G is essentially independent of the void content for low values of v (<5 per cent). Thus d_0 may be determined independently of d by measuring G. Measurement of d by standard methods (gradient tube[4] or water displacement) then allows the determination of v.

Apparatus and Test Procedure

The torsion pendulum is a well-known instrument but has only been profitably applied to scientific problems in the last few years. Extensive experiments were made on metals by Zener and Ke (3) using an instrument essentially similar to the one described here. Plastics have been studied by the torsion pendulum by Schmieder and Wolf (4), Nielsen and Buchdahl (5), and McCrum (6). These authors studied both the torsion modulus and internal friction (mechanical damping)

N. G. McCRUM completed his B.A. degree at Oxford in 1951. He received the Ph.D. degree in 1954 at the Claredon Laboratory in Oxford. During 1954 to 1956, he was an assistant professor in the Dept. of Physics at Pennsylvania State University. He joined DuPont in 1956.

* Presented at the meeting of Subcommittee VIII on Research of ASTM Committee D-20 on Plastics, Pittsburgh, Pa., 1958.

[1] Du Pont registered trade-mark.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] Particle sizes are given in ASTM Specification D 1457 – 56 T, 1958 Book of ASTM Standards, Part 9, p. 75.

[4] ASTM Method of Test for Measurement of Density of Plastics by the Density-Gradient Technique (D 1505 – 57 T), 1958 Book of ASTM Standards, Part 9, p. 511.

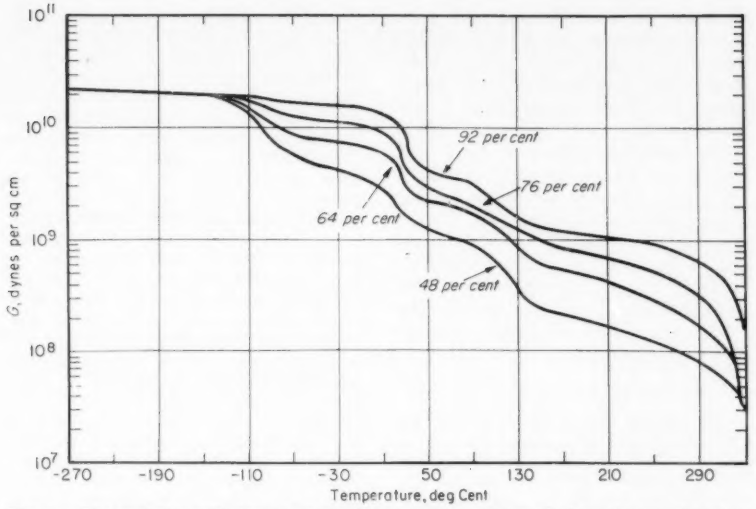


Fig. 1.—The variation with temperature of the torsion modulus G of specimens of various crystallinities made from TFE resins.

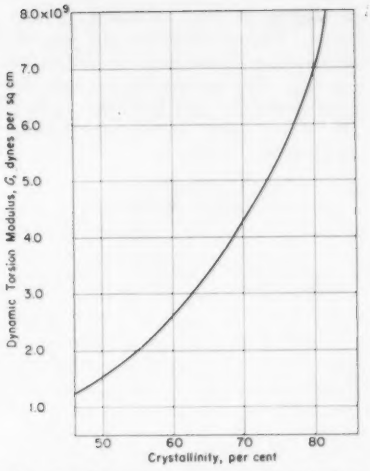


Fig. 2.—The variation of the torsion modulus with crystallinity of specimens molded from TFE resins at 23 C.

over extended temperature regions and consequently used apparatus somewhat more sophisticated and less robust than that required for quality control.

In the apparatus[5] (Fig. 3), specimen A is held rigidly at the top by clamp B and attached by the lower clamp C to the inertia arm D. When the pendulum is rotated from its equilibrium, it will perform torsional oscillations around the vertical axis of the specimen. The period of the oscillation is governed by the geometry and torsion modulus of the specimen and the moment of inertia of the arm D. The period is measured by observing the oscillation of a light beam reflected from the mirror E. The optical system is a simple galvanometer lamp and scale. A small reference pointer mounted under one of the weights on the inertia arm D may be substituted for the optical system. The period of the pendulum is measured by observing the movement of the inertia arm over the pointer. The rugged tripod frame is designed to prevent rocking or wobbling of the equipment. Leveling is achieved by means of three adjustable screws, F, and the bubble level, G. The pendulum is excited into oscillation by passing a short burst of current through the electromagnets, H.

After measuring the period of the free oscillation of the pendulum, the torsion modulus is calculated in the following way. The torsion modulus in dynes per square centimeter for specimens of rectangular cross-section is given by:

$$G = \frac{4\pi^2 Ml}{NT^2} - \frac{mga^2}{12N} \quad \ldots\ldots(2)$$

[5] Torsion pendulums of this type are manufactured by Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Waltham, 54, Mass., and Oak Engineering Co., 110 Monmouth St., Gloucester City, N.J.

where:

M = moment of inertia of the system, g sq cm,
l = length of the specimen, cm,
T = period of the oscillation, sec,
m = mass of the inertia arm, g,
g = acceleration of gravity, cm per sec per sec, and
N = geometrical form factor given:

$$N = \tfrac{1}{3}ab^3\,[1 - 0.63\,(b/a)] \quad \ldots\ldots(3)$$

where:

a = the breadth of the specimen, cm and,

b = the thickness, cm

Equation 3 holds only for specimens for which $b/a \leq \frac{1}{3}$. The second term on the right-hand side of Eq 2 is often negligible for thick specimens or those of high crystallinity. The size of the specimens used in obtaining the correlation between torsion modulus and crystallinity was 3 by 0.50 by 0.060 in. This is the size that is recommended as a standard for quality control. Specimens longer than 3 in. and thicknesses ranging from 0.030 to 0.120 in. have been found to give good results.

After the modulus has been determined, the correlation curves shown in Figs. 2 and 4 are used to obtain the crystallinity and inherent density. The void content is finally calculated using Eq 1 after determining the apparent density.

It is convenient to measure the period with a stopwatch. It is therefore necessary to use an inertia arm of a size that will cause the period to be of the order of 1 sec. The mechanical damping of TFE resins at room temperature allows the time for 5 or 10 swings to be measured, thus lowering the random error in the measurement of the period. The major error in the measurement of G is caused by inaccuracy in the determination of N since the modulus depends on the third power of the specimen thickness. For a 0.060-in. film, the measurement should be made to better than 0.0005 in. The detailed steps in the measurement of the torsion modulus are given in the Appendix.

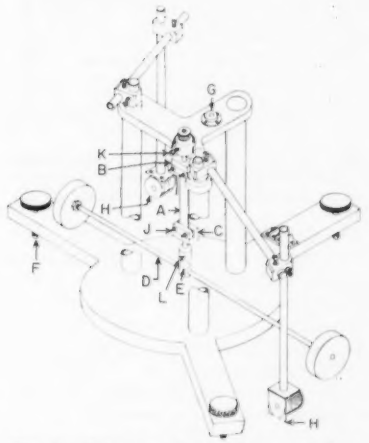


Fig. 3.—Diagram of a torsion pendulum.

Since the modulus depends critically on the form factor N, it is necessary that the specimen dimensions be well defined. In practice we have found the usual thickness variations inherent in compression molded sheets quite tolerable. For instance, in a specimen with $l = 3$ in. and $b = 0.060$ in. a variation in b of ± 0.002 in. does not cause undue error so long as the average value is used in the calculation. The usual tolerances found in machined specimens are more than sufficient.

Details of the Correlation Between Torsion Modulus and Crystallinity

The variation of torsion modulus with inherent density was determined from measurements on a large number

of specimens with different crystallinity. The inherent density was obtained using X-ray and infrared methods (2). The correlation between the torsion modulus at 23 C (in units of 10^9 dynes per square centimeter) and inherent density is,

$$G = 617.242 - 146.4666\,(d_0) - 192.2077\,(d_0^2) + 20.1381\,(d_0^3) + 18.1471\,(d_0^4) \quad (6)$$

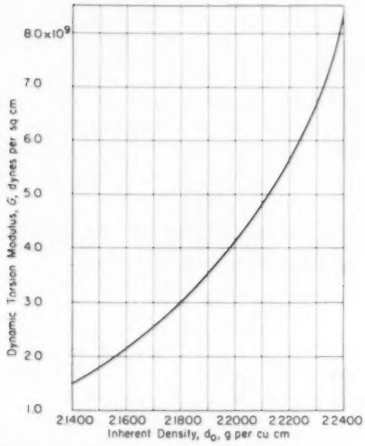


Fig. 4.—The variation of the torsion modulus with inherent density of specimens molded from TFE resins at 23 C.

This function is given in Fig. 4. The relationship between torsion modulus and crystallinity shown in Fig. 2 was determined using a correlation between crystallinity and inherent density. Equation 6 is valid only in the crystallinity range from 45 to 75 per cent. Within these limits, the torsion modulus measurement has a standard deviation, σ of 0.5 per cent. This reproducibility is better than that obtainable with either the X-ray or the infrared methods. The measuring time per specimen is approximately 15 min. If the specimens are all of the same size, then the form factor does not have to be recalculated each time and the measuring time is reduced to about 7 min per specimen.

The calibration given in Eq 6 and Figs. 2 and 4 holds for 23 C, the standard ASTM temperature[6] for the testing of plastics. Unfortunately, the torsion modulus varies rapidly with temperature in the room temperature region as shown in Fig. 1. It is therefore necessary either to make the measurements in a temperature controlled room at 23 C. or to use a correction.

Acknowledgment:

The author wishes to thank W. G. Simeral for several stimulating discussions.

APPENDIX

Detailed Test Procedure

1. Cut the specimen to size.
2. Measure the thickness in four places, take the average of the extreme values and then calculate the form factor N.
3. Place the specimen in the clamps and tighten the locking screws, J, making sure that the specimen and jaws remain in alignment. This procedure may be facilitated by using a small vise to hold the clamps while the screws are tightened.
4. Measure the length, l, of the specimen between the jaws.
5. Clamp specimen and jaws on the stand using the locking screw, K.
6. Attach the inertia arm of the pendulum, D, to the lower clamp using the locking screw, L.
7. Adjust the two electromagnets, H, to be at equal distances from the two pendulum weights. This adjustment may be done with sufficient accuracy by eye.
8. Set the pendulum into oscillation by passing current through the electromagnets. Care must be taken not to cause the pendulum to swing from side to side. This may be checked by observing the path of the light spot on the scale. The spot should move along a horizontal line caused by purely torsional oscillations of the pendulum. If swinging is observed, then at once check to see if the electromagnets are equidistant from the pendulum weights. Swinging may also be caused by passing too much current through the electromagnets for too long a time. The skilled operator will excite the pendulum with short bursts of current in phase with the pendulum oscillation.
9. After the pendulum is in oscillation, record the time for 5 or 10 complete oscillations. We have found the following procedure satisfactory. The hair line is set on the zero mark of the scale. The pendulum is then set into oscillation say with amplitude of about ±5 cm with the scale 100 cm from the mirror. A stopwatch is started as the hair line moves through the zero mark in one direction. The first oscillation is completed when the hair line next moves through the zero mark *in the same direction*. After exciting allow one or two free oscillations to pass before starting to record.
10. Compute the torsion modulus, G.

[6] ASTM Methods of Conditioning Plastics and Electrical Insulating Materials for Testing (D 618 - 58), 1958 Book of ASTM Standards, Part 9, p. 591.

References

(1) P. E. Thomas, *et al.*, "Effects of Fabrication on the Properties of the 'Teflon' Resins," *Journal*, Soc. Plastics Engrs., Vol. 12, No. 6, June (1956).

(2) R. E. Moynihan, *Journal*, Am. Chem. Soc., Vol. 81, pp. 1045–1050 (1959).

(3) T. S. Ke, "Experimental Evidence of the Viscous Nature of Grain Boundaries in Metals," *Physical Review*, Vol. 71, p. 533 (1947).

(4) K. Schmieder and K. Wolf, "The Temperature and Frequency Dependence of the Mechanical Behavior of Some High Polymers," *Kolloid-Zeitschrift*, Vol. 127, p. 65 (1952).

(5) L. E. Nielsen and R. Buchdahl, "Dynamic Mechanical Properties of Plastic Materials," *Journal*, Soc. Plastics Engrs., Vol. 9, May (1953).

(6) N. G. McCrum, "An Internal Friction Study of Polytetrafluoroethylene," International High Polymer Conference, Nottingham, 1958. *Journal of Polymer Science*, Vol. 34, No. 335, Jan. (1959).

Random Samples. . .

FROM THE CURRENT MATERIALS NEWS

Seebeck and Peltier Effects

TRANSFORMING ELECTRICITY into heat is standard practice in household appliances; soon it may be equally familiar to generate electricity directly from a simple heat source. And there is progress toward the use of electric current for either heating or cooling, depending on the direction of current flow.

Scientists have known about thermoelectric effects since the early 1800's, but until recently their only practical application has been in thermocouples. Thomas Johann Seebeck is credited with discovering, in 1821, that when two different metals are connected in a closed circuit and one junction is heated, a current flows. Then in 1834 a French watchmaker named Peltier discovered that by passing a current through a junction between two different conductors, he could heat or cool the junction. In the first of these experiments, heat was converted to electricity and in the second, electricity produced heat (or cooling).

Seebeck's and Peltier's discoveries were not thoroughly understood at first, and in any event the effects they observed were so small that nobody thought seriously of using them for even modest-scale power generation, or heating or cooling. Moreover, applications of electromagnetism developed so rapidly in the 19th century that all attention was turned to rotating electrical machinery and the best possible metal conductors of electricity, such as copper. But the best conductors are poor performers in thermoelectric devices; it was not until improved semiconductor materials became available in quantity, and better understood, that reasonably efficient thermoelectric equipment could be designed.

Consider what happens when heat is applied to one point on a wire. Electrons are boiled away from that point, and the normal distribution of electrical charge is disrupted; as long as the electrons continue to flow, there is an electrical current—which is, exactly, a flow of electrons. This is the Seebeck effect. Now in a metal, there are so many electrons floating around freely, as it were, that they tend to overcome the heat-produced flow, and the total thermoelectric effect is small. But in a semiconductor, there are many fewer free electrons and the imbalance of charges can be sustained more easily.

There is a further advantage to semiconductors; some of them (p-types) produce a net *negative* charge at the point of heating, while others (n-types) produce a net *positive* charge (boiling away of electrons). So the Seebeck effect is enhanced by joining an n-type semiconductor to a p-type semiconductor and heating the junction. The most efficient thermoelectric generators are those in which there is an optimum choice among the electrical conductivity, the thermal conductivity, and the inherent voltage-generating properties of the materials of the junction.

The Peltier effect follows when a current flows across a junction of two dissimilar materials—metals or semiconductors. The average energy of the free electrons in one material will be higher than in the other; thus when a current flows across their junction, the flowing electrons will have to acquire energy to make the jump upward, or release it as they go downward, to conform to the average. If the current flow is from low energy to high, the electrons gain their energy to make the jump by extracting heat energy from the surroundings; this is refrigeration. If the current direction is reversed, the electrons release their excess energy as heat. The maximum Peltier effect is produced by joining a good n-type semiconductor to a good p-type.

According to one authority, the best materials developed to date convert heat to electricity (Seebeck effect) with an efficiency of 10 per cent, whereas a large steam turbine may be 30 per cent efficient. But the higher the temperature difference across a thermoelectric cell, the greater its efficiency, and one of the major objectives of present-day research is to develop thermoelectric materials that will withstand high temperatures. If the cool end were to operate at room temperature and the hot end at 600 C, for example, efficiency could reach 18 per cent in certain instances. Many semiconducting materials, including a large number of alloys and compounds, have already been investigated; certain kinds of ceramics show great promise for efficient operation at temperatures above 1000 C.

To meet low power requirements, a simple thermoelectric power generator may be adequate even at relatively low efficiency. In some rural areas in the U.S.S.R. and China, for example, ordinary kerosine lamps fitted with semiconducting elements are being used to supply power for radio sets, and a Peltier-effect refrigerator is available to Russian city dwellers. In this country, thermoelectric devices have been developed for use in cooling biological objects, such as organic tissue, for microscopic examination; thermostatic control of transistors and other electronic parts; and dew meters. And since almost all heat engines produce large amounts of waste heat at temperatures suitable for the operation of thermoelectric generators, a great number of applications can be looked for in the future.

Thermoelectricity already shows promise in the area of space technology. The "atomic" generator to power the instruments in a satellite, recently announced by the White House, is actually a thermoelectric device powered by heat from radioactive waste materials from a nuclear reactor, normally discarded. Another possibility is to use a reflector mounted on the satellite and aimed constantly at the sun; solar energy would keep a junction of thermoelectric materials hot while the other end of the device, pointed away from the reflector, would be cold. Similarly, thermoelectric devices could be used in rockets where large amounts of waste heat are available.

Industrial Bulletin,
Arthur D. Little Co.,
March, 1956

Muffler Replacement to Be Muffled

PORCELAIN ENAMEL is now making its appearance in the modern automobile. The superior resistance of this ceramic material to acids, corrosive gases, and moisture conditions makes it a "natural" as a coating for automobile mufflers and tail pipes. The hold-up until recently has been the cost. Now, with the advent of the one-coat system, porcelain-enameled mufflers are competitive pricewise with premium-priced mufflers, while having considerably longer life.

A 100,000-mile lifetime warranty is claimed by the Bettinger Corp., Milford, Mass. This has been verified by operating tests in trucks over the past seven years and by extensive tests duplicating operating conditions for a full lifetime of automobile use, estimated to be 104,000 miles or 11 years by the American Automobile Assn.

Bookshelf

Books reviewed here are furnished by publishers knowing of the broad interests of ASTM. Occasionally reviews are prepared by ASTM Staff members, but in most cases, the books are reviewed by Society members or other individuals who are well informed on the subject at hand. Members who wish to be considered for reviewing books are invited to send in their names and the subjects in which they are interested. Due to customs and mailing considerations, requests from the United States only can be considered.

Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure

National Bureau of Standards Handbook 69, U. S. Government Printing Office, 96 pp, 35 cents.

THIS HANDBOOK contains the latest recommendations of the National Committee on Radiation Protection and Measurements (NCRP) concerning the maximum permissible internal exposure of the human body to radioisotopes. These recommendations are a revision of the ones published by the NCRP in 1953.

The 1953 recommendations were for occupational exposure 24 hr per day, continuously for 70 yr. Prepared by the Subcommittee on Permissible Internal Dose, the study took five years to complete and included nearly 75 radioisotopes.

The work has continued at an accelerated pace since 1953 with the added cooperation of the International Commission on Radiological Protection (IRCP). The present handbook includes maximum permissible concentrations and body burdens for some 240 radioisotopes and includes many refinements based on knowledge not available in 1953. The study included the evaluation of nearly 2000 separate researches reported in the literature, having bearing on the permissible dose problem.

The new values reflect, where applicable, the lowering of the basic maximum permissible dose recommended by the NCRP in 1957 and 1958. As a result of all of these considerations some values have been increased, some decreased, and others remain essentially the same. In addition, the continuous occupational exposure has been reduced from 70 to 50 years, a more realistic figure for radiation workers. All maximum permissible concentrations are given for both 40- and 168-hr weeks.

The recommendations in this handbook are to be considered only as recommendations of a group of experts in the radiological protection field. They carry no legal force requiring or demanding adoption.

The Presentation of Technical Information

Reginald O. Kapp; The Macmillan Co. (1958); 148 pp.; $2.95.

"THE ENGLISH LANGUAGE is the most important scientific instrument at your disposal. Learn to use it with precision." These words, by Prof. C. W. Foulk, Ohio State University, should be engraved on the covers of all the many books on technical writing that have been making their appearance lately, including this one by Prof. Kapp, Dean of the Faculty of Engineering, University of London. The trouble is, not many engineers or scientists believe these words. We would suggest to the disbelievers that they try to get through one working day without using this instrument.

The scientific revolution that is upon us, whose roots lie in World War II, is choking our channels of communication with great clots of undigested technical information. The problem is growing—how is all this material to be swallowed by those who need it? It would be helpful if those who write the words in the first place—and this includes more and more of us all the time—took care to see that it is more digestible. But Prof. Kapp makes another telling point: more and more readers are being exposed to technical and semitechnical writing. Foreign readers, in particular, may often read more technical than nontechnical English. As authors, we have an additional responsibility—a responsibility to our language, which is a precious heritage from the past, and whose richness we must protect from dilution by easy, cheap, and clumsy modes of expression. We must not allow the language to become as drab as some industrial towns. We must not permit ugly, tortuous, meaningless language to become common currency through our influence. In this sense, every writer of a technical paper is wearing the mantle of Shakespeare.

But many technical people (most, probably) feel their time is too valuable for English. They feel superior to the need for developing a mere craftsmanship. Or else it has never occurred to them that the task of transferring thought from one head to another is one requiring the best that is in them. Their attitude, in the words of Prof. Kapp, is "Let those who want the ore dig for it."

For the others, the vast minority of technical people who wish to improve their powers of communication and do their bit for the salvation of their mother tongue, Prof. Kapp has provided a distinctly worth-while aid. To fill the more elementary and more immediate needs, he treats such topics as circumlocutions; generalizations; excessive objectivity and its associated evil, overqualification; carelessness the breeder of illogic; and precision in the use of words.

Mastery of the fundamentals can help us all to write simply, clearly, and briefly. If all of us were to achieve this, the millennium would have arrived. But Prof. Kapp asks for more: in addition to simplicity, clarity, and brevity, he asks that we achieve grace. To this end, he discusses more advanced topics (advanced, that is, for engineers) such as: comparison of functional and imaginative literature; psychology of learning, associating, and remembering; use of metaphor; pace and timing; transitions; and use of analogy. We think this effort is very noble, but, for our part, we are willing to settle for simplicity, clarity, and brevity.

A.Q.M.

Sixth Report of the Corrosion Committee

Special Report No. 66, British Iron and Steel Research Assn., 140 Battersea Park Road, London, S.W. 11, England (1958); 217 pp.

SINCE 1938, RESEARCH workers, particularly those dealing with natural media corrosion, have missed the periodic reports of the Corrosion Committee of the Iron and Steel Institute (British). Now the results of nearly 30 years' testing of ferrous materials by that organization are available.

Many of the investigations were in the nature of service tests and are thus of more practical value than are many accelerated laboratory tests.

The committee has substantiated data published elsewhere concerning the beneficial effects of small amounts of copper, nickel, and other alloying elements on the atmospheric corrosion resistance of steel, but not on the resistance to fresh or sea water. In the latter environment, about 3 per cent of chromium was found to cut the corrosion rate in half; the other alloying elements were not effective.

Considerable work has been done on painting steel. The importance of adequate surface preparation is emphasized, and the longer life of paint films when on the more corrosion-resistant steels and exposed to industrial atmosphere is shown.

Corrosion prevention at temperatures up to 300 C is covered in 23 pages. This chapter is well worth-while because relatively little has been published on this phase of corrosion prevention.

The publication is not a treatise on corrosion; hence, very few literature references are given other than to the published papers of the committee. The book is a particularly valuable reference because it summarizes much of the work of the committee in one volume.

C. P. LARRABEE

(*Continued on page 117*)

ASTM Bulletin Index

Author Index

(*R*) denotes 10 or more references.

A

Achter, M. R.
See Danek, G. J., Jr. and Achter, M. R.
Alden, R. C.
Research Comes First, ACR notes, No. 235, Jan., 25.
Allen, J. G. and Wood, J. C. S.
Fluorescent Indicator Absorption Analysis Using the Chromanalyzer, No. 238, May, 49 (TP 117).
Armstrong, Ellis L.
Research Today. . .for Better Roads Tomorrow—Condensation of an address, 62nd ASTM Annual Meeting, No. 241, Oct., 14.

B

Barron, L. A.
Discussion, No. 241, Oct., 26 (TP 190).
Benjamin, Irwin A. and Ratliff, George D., Jr.
An In-Place Strength Test for Low-Density Concrete, No. 241, Oct., 23 (TP 187). Disc., 25 (TP 189).
Berman, H. A.
An Improved 8-Hydroxyquinoline Method for the Determination of Magnesium Oxide in Portland Cement, No. 237, April, 51 (TP 71).
Birks, A. M. and Rudin, A.
Control of Thermal History of Polyethylene Test Specimens, No. 242, Dec., 63 (TP 223).
Birks, L. S.
Discussion, No. 235, Jan., 51 (TP 21).
Birmingham, B. W., Chelton, D. B., Mann, D. B., and Hernandez, H. P.
Cryogenic Engineering of Hydrogen Bubble Chambers, No. 240, Sept., 34 (TP 164) (*R*).
Blank, E. W.
See Kelley, R. M., Blank, E. W., Thompson, W. E., and Fine, R.
Box, W. D.
A Powder Explosibility Tester with Continuous Feed, No. 241, Oct., 34 (TP 198) (*R*).
Brennan, E. W.
Demulsibility of High Viscosity Oils—Report of Technical Committee C on Turbine Oils of ASTM Committee D-2 on Petroleum Products and Lubricants, No. 242, Dec., 75 (TP 234).
Brightwell, E. P.
High Precision Nondestructive Thickness Measurements of Organic Coatings, No. 237, April, 67 (TP 87).

C

Cahn, Harold L. and Mackey, Royal V., Jr.
Extending Concrete Highway Durability and Light Reflectance with Silicones, No. 235, Jan., 37 (TP 7). Disc., 41 (TP 11).
Chaiken, Bernard
Determination of Ignition Loss in Portland Blast-Furnace Slag Cements, No. 238, May, 53 (TP 121).
Chambers, R. E. and McGarry, F. J.
Shear Effects in Glass Fiber Reinforced Plastics Laminates, No. 238, May 38 (TP 106).
Chelton, D. B.
See Birmingham, B. W., Chelton, D. B., Mann, D. B., and Hernandez, H. P.
Chisholm, R. A.
Discussion, No. 235, Jan., 36 (TP 6).
Copson, H. R. and Larrabee, C. P.
"Extra Durability of Paint on Low-Alloy Steels," No. 242, Dec., 68 (TP 228).

D

Danek, G. J., Jr. and Achter, M. R.
A Servomechanism for Vacuum and Controlled-Environment Fatigue Testing, No. 239, July 80 (TP 160). (Technical Note).
Desai, M. B. and McGarry, F. J.
Failure Mechanisms in Glass Fiber Reinforced Plastics, No. 239, July, 76 (TP 156).
Diamond, Arthur S.
A New Method for Determining the Wet Adherence of Supported Films to Various Bases, No. 236, Feb., 48 (TP 58) (*R*).
Dill, F. H.
Discussion, No. 241, Oct., 37 (TP 201).
Dillon, C. P.
Discussion, No. 235, Jan., 44 (TP 14).
Dolan, Thomas J.
Basic Research in Fatigue of Metals, No. 240, Sept., 24 (*R*).
Doyle, C. D. and Olszewski, W. V.
Specimen Deflection Determination from Crosshead Travel in Three - Point Flexure Test, No. 241, Oct., 44 (TP 208).
Dranichak, Michael
Discussion, No. 235, Jan., 41 (TP 11).
Dunnington, Bruce W.
See Stang, John H., Goldthwaite, William H., and Dunnington, Bruce W.

E

Edgerton, N. W.
Discussion, No. 237, April, 67 (TP 87).
Ehlers, G. F. L.
A Modified Vicat Type Apparatus for Measuring the Softening Point of Thermosetting Plastics and Laminates, No. 236, Feb. 54 (TP 64). Disc., No. 241, Oct., 40 (TP 204).
Engdahl, R. B. and Sullivan, J. D.
Municipal Incinerator Refractories Practice, No. 240, Sept., 52 (*TP* 182).
Ek, C. Harold
See Hawkes, Paul E. and Ek, C. Harold
Ewell, Raymond
Soviet Russia Poses a New Industrial Threat, No. 239, July, 43.

F

Fine, R.
See Kelley, R. M., Blank, E. W., Thompson, W. E., and Fine, R.
Fisher, John C.
The Role of Dislocations in Plastic Deformation (of Metals), No. 241, Oct., 6 (synopsis). (Gillett Lecture) (published as separate pamphlet.)
Fouts, J. M.
The Use of Ultrasonics in Testing Irradiated Fuel Elements, No. 242, Dec., 60 (TP 220).

G

Gambrill, C. M.
Expanding Horizons in Analytical Chemistry, No. 239, July, 45.
Gavan, F. M.
Further Development and Use of the Armstrong Sandpaper Abrasion Machine, No. 238, May, 44 (TP 112).
Gerard, George
See Tramposch, Herbert, Papirno, Ralph, and Gerard, George
Gilbraith, Allen C.
A New Steel for Aircraft and Missile Honeycombs, No. 240, Sept., 51 (TP 181). (Technical Note.)
Ginsburg, H.
See Sheppard, H. R. and Ginsburg, H.
Goetz, W. H.
Discussion, No. 235, Jan., 36 (TP 6).
Goldthwaite, William H.
See Stang, John H., Goldthwaite, William H., and Dunnington, Bruce W.
Gonser, B. W.
ACR Notes, No. 242, Dec., 43.
Green, J.
See Peeler, R. L. and Green, J.
Grover, Horace J.
Recent Survey of Current Activities on Fatigue, No. 235, Jan., 26. Report of Subcommittee III on Survey of ASTM Committee E-9 on Fatigue.

H

Hamburger, Walter J.
The Need to Know, No. 238, May 23.
Hansen, W. C.
Release of Alkalies by Sands and Admixtures in Portland Cement Mortars, No. 236, Feb., 35 (TP 45).
Harris, Jay C.
Committee Work and Fundamental Research, No. 238, May, 18.
Hatch, H. P.
Discussion, No. 235, Jan., 41 (TP 11).
Hawkes, Paul E. and Ek, C. Harold
A Machine for Evaluation of High-Temperature Alloys Under Combined Static and Dynamic Stresses, No. 235, Jan., 46 (TP 16). Disc., 51 (TP 21).
Hernandez, H. P.
See Birmingham, B. W., Chelton, D. B. Mann, D. B., and Hernandez, H. P.
Hodgins, P. T.
The Effect of Brick Facial Texture Upon the Initial Rate of Absorption, No. 241, Oct., 27 (TP 191).

J

Johnson, C. A.
Electrical Insulating Liquids 1916–1959—The Story of Subcommittee IV, Committee D-9, No. 238, May, 25.
Juve, A. E.
Mooney Cure Tests for Calculating Curing Times, No. 239, July, 71 (TP 151).

K

Kampf, Leo
Discussion, No. 240, Sept., 45 (TP 175).
Kaups, Taavi
Discussion, No. 239, July, 79 (TP 159).
Kelley, R. M., Blank, E. W., Thompson, W. E., and Fine, R.
The Determination of Alkyl Aryl Sulfonates by Ultraviolet Absorption, No. 237, April, 70 (TP 90) (*R*).
Klieger, Paul
Discussion, No. 235, Jan., 41 (TP 11).
Kolloff, R. H.
Analysis of Commercial Sodium Tripolyphosphate by Reverse Flow Ion Exchange Chromatography, No. 237, April, 74 (TP 94) (*R*).
Kropschot, R. H.
See McClintock, R. M., Van Gundy, D. A., and Kropschot, R. H.
Kuenning, William H.
Discussion, No. 241, Oct., 26 (TP 190).
Kula, Erick, B., and Larson, Frank R.
Effect of Specimen Taper on Determination of Elongation in the Tension Test, No. 238, May, 58 (TP 126). Disc., No. 241, Oct., 37 (TP 201).

L

Larrabee, C. P.
See Copson, H. R. and Larrabee, C. P.
Larson, Frank R.
See Kula, Eric B. and Larson, Frank R.
Lashof, T. W.
See Mandel, John and Lashof, T. W.
Laskie, J. R.
The Use of Molded Activated Carbon Getters in Sealed Electrical Instruments, No. 241, Oct., 41 (TP 205). (Technical Note.)
Legget, Robert F.
Common Sense and Building Materials, No. 237, April, 36.

Long, Augustus C.
Business Man Abroad, No. 237, April, 28.
Lubahn, J. D.
The Effect of Temperature Interruption on Anelastic Creep, No. 239, July, 61 (TP 141). (Technical Note.)

M

Mackey, Royal V., Jr.
See Cahn, Harold L. and Mackey, Royal V., Jr.
Mandel, John
The Theory of Extreme Values, No. 236, Feb., 29 (TP 39) (*R*).
Mandel, John and Lashof, T. W.
The Interlaboratory Evaluation of Testing Methods, No. 239, July, 53 (TP 133).
Mann, D. B.
See Birmingham, B. W., Chelton, D. B., Mann, D. B., and Hernandez, H. P.
Mark, Herman F.
New Polymers—New Problems, No. 241, Oct., 6 (synopsis). (Marburg Lecture.) (published as separate pamphlet)
McClintock, R. M., Van Gundy, D. A., and Kropschot, R. H.
Low-Temperature Tensile Properties of Copper and Four Bronzes, No. 240, Sept., 47 (TP 177).
McCoy, Ernest E., Jr.
Discussion No. 236, Feb., 47 (TP 57).
McCrum, N. G.
Torsion Pendulum Method for Determining Crystallinity and Void Content of Tetrafluoroethylene Resins, No. 242, Dec., 80 (TP 240).
McGarry, F. J.
Resin-Glass Bond Characteristics, No. 235, Jan., 63 (TP 33).
See Chambers, R. E. and McGarry, F. J.
See Desai, M. B. and McGarry, F. J.
McMullin, J. G. and Yukawa, S.
See Yukawa, S. and McMullin, J. G.
McPherson, Archibald T.
Science Fairs, ACR notes, No. 237, April, 29.
Metzger, Paul D.
Wheeling Steel Method for Determining the Demulsibility of Lubricating Oils, No. 242, Dec., 77 (TP 237).
Miller, N. R.
Discussion, No. 241, Oct., 40 (TP 204).
Mills, Blake D., Jr.
Disc., No. 236, Feb., 47 (TP 57).
Monego, C. J.
See Wing, Paul and Monego, C. J.
Moorehead, D. R. and Taylor, W. H.
The Sucrose Extraction Method of Determining Available Calcium Oxide in Hydrated Lime, No. 236, Feb., 45 (TP 55).
Moran, J. J.
See Ruh, E. L., Moran, J. J., and Thompson, R. D.
Mowbray, A. Q.
A Pig Is a Pig Is a Pig, No. 241, Oct., 18.

N

Neisel, R. H.
Prediction of Temperature Rise in Fire Testing of Walls and Partitions, No. 239, July, 66 (TP 146).
Nelson, G. A.
Residual Stresses in Heat-Exchanger Tubes, No. 240, Sept., 39 (TP 169). (Technical Note.)
Neville, A. M.
The Influence of the Direction of Loading on the Strength of Concrete Test Cubes, No. 239, July, 63 (TP 143).
Newton, Clarence J.
False Negative Permanent Strains Observed with Resistance Wire Strain Gages, No. 235, Jan., 42 (TP 12). Disc., No. 239, July, 79 (TP 159).
Nizodemus, P. O.
The Significance of Iron in Asbestos Materials Used for Electrical Insulating Purposes, No. 237, April, 62 (TP 82). Disc., 67 (TP 87).

O

O'Kelly, B. M.
Physical Changes in Setting Gypsum Plaster, No. 237, April, 55 (TP 75) (*R*).
Oliensis, G. L.
Discussion, No. 235, Jan., 36 (TP 6).
Olszewski, W. V.
See Doyle, C. D. and Olszewski, W. V.

P

Papirno, Ralph
See Tramposch, Herbert, Papirno, Ralph, and Gerard, George
Peckner, D.
Segregation in Aluminum—13 Per Cent Uranium Castings, No. 242, Dec., 51 (TP 211).
Peeler, R. L. and Green, J.
Measurement of Bulk Modulus of Hydraulic Fluids, No. 235, Jan., 51 (TP 21 (*R*).
Phelan, Paul F.
Discussion, No. 235, Jan., 36 (TP 6).

R

Ratliff, George D., Jr.
See Benjamin, Irwin A. and Ratliff, George D., Jr.
Rogers, P. L.
A Method of Test for Potential Effluorescence of Masonry Mortar, No. 235, Jan., 31 (TP 1). Disc., No. 240, Sept., 45 (TP 175).
Rudin, A.
See Birks, A. M. and Rudin, A.
Ruh, E. L., Moran, J. J., and Thompson, R. D.
Measurement Problems in the Instrument and Laboratory Apparatus Field no. 240, Sept., 31 (TP 161).

S

Samans, C. H.
See Tisinai, G. F. and Samans, C. H.
Schlabach, Tom D.
The Temperature Dependence of Electrical Resistivity of Laminated Thermoset Materials, No. 238, May, 33 (TP 101) (*R*).
Schniewind, Arno P.
An Improved and Semi-Automatic Method of Conducting the Standard Hardness Test for Timber, No. 236, Feb., 57 (TP 67).
Schutz, R. J. and Van Hanter, A.
New Concrete Joint Sealant Testing Machine, No. 241, Oct., 42 (TP 206).
Sereda, P. J.
Measurement of Surface Moisture, No. 238, May, 61 (TP 129). Second Progress Report.
Shapiro, J. J.
See Winslow, N. M. and Shapiro, J. J.
Sheppard, H. R. and Ginsburg, H.
Should Statistical Methods Be Used to Prepare Materials Specifications, No. 236, Feb., 31 (TP 41).
Sherman, Morton
Discussion, No. 241, Oct., 25 (TP 189).
Shobert, Erle I., II
Cooperation on Research Problems, ACR notes, No. 239, July, 50.
Sisco, Frank T.
Further Thoughts of Making Engineering Literature Available, ACR notes, No. 240, Sept., 30.
Smith, Walter J.
A Promising Trend in Student Employment, ACR notes, No. 241, Oct., 21.
Soroka, I.
Water-Retardant Qualities of External Coatings, No. 240, Sept., 40 (TP 170) (*R*).
Speight, F. Y.
Application of Statistics, No. 236, Feb., 29 (TP 39).
Stang, John H., Goldthwaite, William H., and Dunnington, Bruce W.
Design Studies of Capsules for High-Temperature Irradiations, No. 242, Dec., 54 (TP 214).
Stein, Peter
Discussion, No. 239, July, 79 (TP 159).
Strella, S.
An Improved High-Speed Tension Tester, No. 236, Feb., 59 (TP 69). (Technical Notes.)
Sullivan, J. D.
See Engdahl, R. B. and Sullivan, J. D.

T

Taylor, W. H.
See Moorehead, D. R. and Taylor, W. H.
Thomas, J. P.
Accelerated Aging Tests and Life Aging Properties of Aircraft Metal Adhesives, No. 235, Jan., 58 (TP 28).
Thompson, R. D.
See Ruh, E. L., Moran, J. J., and Thompson, R. D.
Thompson, W. E.
See Kelley, R. M., Blank, E. W., Thompson, W. E., and Fine, R.
Tisiani, G. F. and Samans, C. H.
Additional Studies with an All-Glass Multiple-Test Apparatus for Nitric Acid Testing of Stainless Steels, No. 238, May, 64 (TP 132). (Technical Note.)
Toolin, P. R.
Discussion, No. 235, Jan., 51 (TP 21).
Townsend, J. R.
International Standards, ACR notes, No. 236, Feb., 15.
Tramposch, Herbert, Papirno, Ralph, and Gerard George
A Rapid Scanning System for Recording Thermocouple Outputs, No. 238, May, 41 (TP 109). (Technical Note.)

V

Van Gundy, D. A.
See McClintock, R. M., Van Gundy, D. A., and Kropschot, R. H.
Van Hauter, A.
See Schutz, R. J. and Van Hauter, A.
Vreeland, T., Jr.
Discussion, No. 236, Feb., 47 (TP 57).

W

Walker, Eric A.
Why Don't Engineers Learn to Write? address, education luncheon, 62nd Annual Meeting (excerpt).
Warden, W. B.
Discussion, No. 235, Jan., 36 (TP 6).
Warren, Donald
Nitric Hydrofluoric Acid Evaluation Test for Type 316 L Stainless Steel, Disc. No. 235, Jan., 44 (TP 14).
Wing, Paul and Monego, C. J.
Thermal Insulation Measurements on Textiles—A Comparison of Two Methods, No. 241, Oct., 29 (TP 193).
Wood, J. C. S.
See Allen, J. G. and Wood, J. C. S.
Wood, J. Eldridge
Discussion, No. 235, Jan., 36 (TP 6).
Woods, K. B.
The Impact of Science on ASTM—The President's Address, ASTM 62nd Annua Meeting, No. 239, July, 9.
Winslow, N. M. and Shapiro, J. J.
An Instrument for the Measurement of Pore-Size Distribution by Mercury Penetration, No. 236, Feb., 39 (TP 49) (*R*).
Wycoff, John C.
Suitability of Lightweight Aggregate for Bituminous Plant Mix, No. 235, Jan., 33 (TP 3). Disc., 36 (TP 6).

Y

Yukawa, S. and McMullin, J. G.
High-Stress, Low-Cycle Fatigue Properties of Notched Alloy Steel Specimens, No. 241, Oct., 38 (TP 202).

Subject Index

A

Abraders
sandpaper machine
for testing floor coverings (Gavan), No. 238, May, 44 (TP 112).
ACR Notes, No. 235, Jan., 25; No. 236, Feb., 15; No. 237, April, 29; No. 239, July, 50; No. 240, Sept., 30; No. 241, Oct., 21; No. 242, Dec., 43.
See also Research
Activated Carbon
organic contaminant adsorbent (Laskie), No. 241, Oct., 41 (TP 205).

Advertising
importance to the technical man, No. 240, directory of ASTM advertisers No. 240, Sept., 57
Adhesives
for aircraft metal structures (Thomas), No. 235, Jan., 58 (TP 28).
See also Laminates
Aging Test
for aircraft metal adhesives (Thomas), No. 235, Jan., 58 (TP 28).
Aggregates
lightweight
from bituminous plant mix (Wycoff), No. 235, Jan., 33 (TP 3). Disc., 36 (TP 6).
Aircraft and Missile Materials
stainless-steel honeycombs (Gilbraith), No. 240, Sept., 51 (TP 181). Disc., 36 (TP 6).
Aluminum
alloys
long-range segregation of uranium (Peckner), No. 242, Dec., 51 (TP 211).
appearance measuring (Paulson), No. 242, Dec., 33.
American Standards Association
approves ASTM standards as American Standard, No. 236, Feb., 14; No. 237, April 29; No. 238, May 17; No. 239, July, 51.
Analytical Chemistry
expanding horizons (Gambrill), No. 239, July, 45.
Appearance
in aluminum surfaces (Paulson), No. 242, Dec., 33
Asbestos Materials
for electrical insulation
iron content rate (Nicodemus), No. 237, April, 62 (TP 82), Disc., 67 (TP 87).
ASTM
and impact of science, President's address (Woods), No. 239, July 9.
and the critical data problem, No. 236, Feb., 16.
awards of merit, No. 239, July 24.
directory of advertisers, No. 240, Sept., 57.
finances—1958, No. 236, Feb., 10.
honorary members elected 1959, No. 239, July, 23.
in 1958, No. 235, Jan., 5.
materials and progress (LaQue), No. 242, Dec., 20.
national officers elected 1959, No. 239, July, 20.
new division on materials sciences, No. 236, Feb., 5.
property
headquarters, additional acquisition, No. 236, Feb., 9.
publications 1959–1960, No. 241, Oct., 5.
reports file, No. 241, Oct., 12.
test sites, No. 236, Feb., 24.
two new technical committees, No. 237, April, 48.
Atmospheric Exposure
ASTM test sites (Advisory Committee on Corrosion), No. 236, Feb., 24.
Awards, No. 236, Feb., 23; No. 239, July, 24; citations for quality of presentation, No. 239, July, 22.
committee D-12, J. C. Harris—1959 recipient No. 236, Feb., 23.
Harold De Witt Smith, address (Hamburger), No. 238, May, 23.
honorary members, No. 239, July, 23.
of merit (ASTM), No. 239, July, 24.

B

Bituminous Materials
highway construction (Armstrong), No. 241, Oct., 14.
Bituminous Mixtures
lightweight aggregates (Wycoff), No. 235, Jan., 33 (TP 3). Disc., 36 (TP 6).
Brick
rate of moisture absorption (Hodgins), No. 241, Oct., 27 (TP 191).
Bronze
tensile properties
effect of low-temperature (McClintock, Van Gundy, and Kropschot), No. 240, Sept., 47 (TP 177).
Building Materials
codes and standards (Legget), No. 237, April, 36.
Bulk Modulus
measurement of
in hydraulic fluids (Peeler and Green), No. 235, Jan., 51 (TP 21) (*R*).

C

Calcium Oxide
in hydrated lime (Moorehead and Taylor), No. 236, Feb., 45 (TP 55).
Capsules
for high-temperature irradiations (Stang, Goldthwaite, and Dunnington), No. 242, Dec., 54 (TP 214).
Cement
highway construction (Armstrong), No. 241, Oct., 14.
portland
magnesium oxide in (Berman), No. 237, April, 51 (TP 71).
release of alkalies (Hansen), No. 236, Feb., 35 (TP 45).
portland blast-furnace slag
ignition loss (Chaiken), No. 238, May, 53 (TP 121).
proposed method of test
for determining cement content in fresh concrete, No. 239, July, 48.
"Chimney" Test Method
for water-retardant coatings (Soroka), No. 240, Sept., 40 (TP 170) (*R*).
Chromanalyzer
for hydrocarbon analysis of olefinic gasolines (Allen and Wood), No. 238, May, 49 (TP 117).
Chromatography
analysis of sodium tripolyphosphate (Kolloff), No. 237, April, 74 (TP 94) (*R*).
Coatings
organic
thickness measurement
by infrared interferometry (Brightwell), No. 237, April, 67 (TP 87).
water-retardant
"Chimney" test method (Soroka), No. 240, Sept., 40 (TP 170) (*R*).
paint
on steels (Copson and Larrabee), No. 242, Dec., 58 (TP 238).
Coating Materials
wet-abrasion resistance test (Diamond), No. 236, Feb., 48 (TP 58) (*R*).
Committee Work
and fundamental research (Harris), No. 238, May, 18.
Communication
plain language (Mowbray), No. 241, Oct., 18.
Compression Test
concrete cubes
influence of direction of loading (Neville) No. 239, July, 63 (TP 143).
Concrete
cement content of freshly mixed
proposed method of test, No. 239, July, 48.
compression test
influence of direction of loading (Neville), No. 239, July, 63 (TP 143).
highway (Cahn and Mackay, Jr.), No. 235, Jan., 37 (TP 7). Disc., 41 (TP 11).
highway construction (Armstrong), No. 241, Oct., 14.
in-place strength test (Benjamin and Ratliff, Jr.), No. 241, Oct., 23 (TP 187). Disc., 25 (TP 189).
joint sealant materials (Schutz and Van Hauter), No. 241, Oct., 42 (TP 206).
Copper
tensile properties
effect of low-temperature (McClintock, Van Gundy, and Kropschot), No. 240, Sept., 47 (TP 177).
Corrosion
ASTM atmospheric exposure sites (Advisory Committee on Corrosion), No. 236, Feb. 24.
measurement of surface moisture (Sereda), No. 238, May, 61 (TP 129).
stainless steel
nitric acid all-glass multiple-test apparatus (Tisinai and Samans), No. 238, May, 64 (TP 132).
Creep
anelastic
effect of temperature (Lubahn), No. 239, July, 61 (TP 141).
Critical Data
and ASTM, No. 236, Feb., 16.
Cryogenics
hydrogen bubble chambers
engineering of (Birmingham, Chelton, Mann, and Hernandez), No. 240, Sept., 34 (TP 164) (*R*).
Curing
vulcanizable materials
time rates from Mooney test (Juve), No. 239, July, 71 (TP 151).

D

Data Storage and Retrieval
critical, No. 236, Feb., 16.
making engineering literature available, ACR notes, (Sisco), No. 240, Sept., 30.
Demulsibility
of high viscosity oils (Brennan), No. 242, Dec., 75 (TP 235).
of lubricating oils
Wheeling steel method (Metzger), No. 242, Dec., 77 (TP 237).
Detergents
determination of alkyl aryl sulfonates (Kelley, Blank, Thompson, and Fine), No. 237, April, 74 (TP 90) (*R*).
phosphate species
ion exchange chromatography (Kolloff), No. 237, April, 74 (TP 94) (*R*).
fundamental research in (Harris), No. 238, May, 18.
De Witt Smith Medal
Walter J. Hamburger—1959 recipient, No. 236, Feb., 23.
District Activities, No. 235, Jan., 22; No. 236, Feb., 20; No. 237, April, 30; No. 238, May, 20; No. 239, July, 37; No. 240, Sept., 18; No. 241, Oct., 20; No. 242, Dec., 40.

E

Education
in materials (Walker), No. 239, July, 8.
Efflorescence
of masonry mortar
test for (Rogers), No. 235, Jan., 31 (TP 1). Disc., No. 240, Sept., 45 (TP 175).
Electrical Instruments
activated carbon
organic contamination adsorption (Laskie), No. 241, Oct., 41 (TP 205).
Electrical Insulating Liquids
story of Subcommittee IV, Committee D-9, 1916–1959 (Johnson), No. 238, May, 25.
Electrical Insulating Materials
asbestos
iron content rate (Nicodemus), No. 237, April, 62 (TP 82). Disc., 67 (TP 87).
liquids and gases
new ASTM committee (D-27), No. 237, April, 48.
1916–1959, story of ASTM Subcommittee IV, Committee D-9 (Johnson), No. 238, May 25.
laminated thermoset
resistivity (Schlabach), No. 238, May, 33 (TP 101) (*R*).
Eminent Men of Science
biographical notes, photographs, quotations
Bacon, Francis, No. 240, Sept., 26.
Bacon, Roger, No. 241, Oct., 19.
Newton, Sir Isaac, No. 239, July, 42.
Chanute, Octave, No. 242, 49.
Explosibility Tester
for air-suspended solids (Box), No. 241, Oct. 34 (TP 198) (*R*).

F

Fatigue
current activities, Report of Subcommittee III of ASTM Committee E-9, No. 235, Jan., 26.
high-stress, low-cycle properties
notched alloy specimens (Yukawa and McMullin), No. 241, Oct., 38 (TP 202).
high temperature alloys
static and dynamic stresses (Hawkes and Ek), No. 235, Jan., 46 (TP 16). Disc., 51 (TP 21).
metals
basic research (Dolan), No. 240, Sept., 24 (*R*).
tester
servomechanism control system (Danek and Achter), No. 239, July, 80 (TP 160).
FIA Method (with Chromanalyzer)
for hydrocarbon analysis of olefinic gasolines (Allen and Wood), No. 238, May 49 (TP 117).

Films
supported
wet adherence to various bases (Diamond), No. 236, Feb., 48 (TP 58) (*R*).
Fire Testing
endurance test of wall panels
prediction of temperature rise (Neisel), No. 239, July, 66 (TP 146).
Finances
ASTM, 1958, No. 236, Feb., 10.
Flammability
ASTM test method improvements (Eysenbach and Gouza), No. 242, Dec., 62 (TP 222).
Flexure Properties
plastics
three-point test (Doyle and Olszewski), No. 241, Oct., 44 (TP 208).
Floor Coverings
sandpaper-abrasion resistance (Gavan), No 238, May, 44 (TP 112).
Fuels
See Gasolines *and* Oils

G

Gasolines
olefinic, hydrocarbon analysis
FIA method with chromanalyzer (Allen and Wood), No. 238, May, 49 (TP 117).
Glass
bond characteristics, with resin (McGarry), No. 235, Jan., 63 (TP 33).
Glass Fiber
reinforced laminates
flexural modulus (Chambers and McGarry), No. 238, May, 38 (TP 106).
reinforced plastics
failure mechanism (Desai and McGarry), No. 239, July, 76 (TP 156).
"Guarded Hot Plate" Method
textiles
thermal insulating properties (Wing and Monego), No. 241, Oct., 29 (TP 193).
Gypsum
crystals
influence in plaster setting (O'Kelly), No. 237, April, 55 (TP 75) (*R*).

H

Hardness Test
timber
improved and semiautomatic method (Schniewind), No. 236, Feb., 57 (TP 67).
High-Temperature Alloys
static and dynamic stresses (Hawkes and Ek), No. 235, Jan., 46 (TP 16). Disc., 51 (TP 21).
Highway Construction
research for (Armstrong), No. 241, Oct., 14.
Heat Exchanger Tubes
residual stresses (Nelson), No. 240, Sept., 39 (TP 169).
Heavy Liquid Separation Method
proposed tentative test
for determining cement content in freshly mixed concrete, No. 239, July, 48.
Honorary Members of ASTM
elected 1959, No. 239, July, 23.
Hydraulic Fluids
bulk modulus (Peeler and Green), No. 235, Jan., 51 (TP 21) (*R*).
Hydrogen Bubble Chambers
low-temperature materials problems (Birmingham, Chelton, Mann, and Hernandez), No. 240, Sept., 34 (TP 164) (*R*).
8-Hydroxyquinoline Method
portland cement
determination of magnesium oxide (Berman), No. 237, April, 51 (TP 71)

I

Ignition Loss
in portland blast-furnace slag cements (Chaiken), No. 238, May, 53 (TP 121).
Incinerators
municipal, refractories for (Engdahl and Sullivan), No. 240, Sept., 52 (TP 182).
Industrial Chemicals
new ASTM committee (E-15), No. 237, April, 48.
Interlaboratory Tests
evaluation of methods (Mandel and Lashof), No. 239, July, 53 (TP 133).
International Standards
ACR notes (Townsend), No. 236, Feb., 15.
Ion Exchange Chromatography
analysis of commercial sodium tripolyphosphate (Kolloff), No. 237, April, 74 (TP 94) (*R*).
In-Place Strength Test
concrete (Benjamin and Ratliff, Jr.) No. 241, Oct., 23 (TP 187). Disc., 25 (TP 189).
Insulating Materials
asbestos
iron content rate (Nicodemus), No. 237, April, 62 (TP 82). Disc., 67 (TP 87).
See also Electrical Insulating Materials *and* Electrical Insulating Liquids
Ion Exchange Chromatography
determination of phosphate species in detergents (Kolloff), No. 237, April, 74 (TP 94), (*R*).
Iron
in asbestos materials for electrical insulation (Nicodemus), No. 237, April, 62 (TP 82). Disc., 67 (TP 87).

L

Laboratory Apparatus
standardization of measurement units (Ruh, Moran, and Thompson), No. 240, Sept., 31 (TP 161).
Laminates
fiberglass reinforced plastics
failure mechanisms (Desai and McGarry), No. 239, July, 76 (TP 156).
flexural modulus (Chambers and McGarry), No. 238, May, 38 (TP 106).
flexure properties
three-point test (Doyle and Olszewski), No. 241, Oct., 44 (TP 208).
resin-glass
bond characteristics (McGarry), No. 235, Jan., 63 (TP 33).
thermosetting
temperature dependence of electrical resistivity (Schlabach), No. 238, May, 33 (TP 101) (*R*).
See also Plastics
Lectures
Gillett
dislocations in plastic deformation (Fisher), No. 237, April, 7; No. 239, July, 6 (synopsis).
Marburg
new polymers—new problems (Mark), No. 237, April, 7; No. 239, July, 6 (synopsis).
Lime
hydrated
calcium oxide in (Moorehead and Taylor), No. 236, Feb., 45 (TP 55).
Low-Temperature
hydrogen bubble chambers
materials problem (Birmingham, Chelton, Mann, and Hernandez), No. 240, Sept., 34 (TP 164) (*R*).
tensile properties of copper and bronze (McClintock, Van Gundy, and Kropschot), No. 240, Sept., 47 (TP 177).
Lubricants
See Oils

M

Management and Responsibilities
changes (Nason), No. 242, Dec., 28.
purchasing (Cresap, Jr.) No. 242, Dec., 35.
Material Questions, No. 238, May, 12; No. 239, July, 35; No. 240, Sept., 13; No. 241, Oct., 13; No. 242, Dec., 24.
Materials
education in (Walker), No. 239, July, 8; No. 240, Sept., 20.
in aerospace age (Schriever), No. 242, Dec., 16.
needed in 1970. AIA report, No. 240, Sept., 28.
sciences
new ASTM division, No. 236, Feb., 5.
Meetings
Annual Meeting
1959, No. 235, Jan., 20; No. 236, Feb., 6; No. 237, April, 5; No. 238, May, 5; No. 239, July 5; No. 240, Sept., 5.
Committee Week
1959, No. 235, Jan., 19; No. 237, April, 33; No. 242, Dec., 32.
National Conference on Standards, No. 235, Jan. 20.
Third Pacific Area National Meeting, No. 236, Feb., 11; No. 238, May, 8, 24; No. 239, July, 32; No. 240, Sept., 21; No. 242, Dec., 5.
Missile and Aircraft Materials
stainless-steel honeycombs (Gilbraith), No. 240, Sept., 51 (TP 181).
Moisture
brick
rate of absorption (Hodgins), No. 241, Oct., 27 (TP 191).
surface
measurement instrumentation (Sereda), No. 238, May, 61 (TP 129).
Mortar
efflorescence (Rogers), No. 235, Jan., 31 (TP 1). Disc., No. 240, Sept., 45 (TP 175).
portland cement
release of alkalines (Hansen), No. 236, Feb., 35 (TP 45).

N

National Officers of ASTM
elected 1959, No. 239, July, 20.
New Members, No. 235, Jan., 80; No. 236, Feb., 72; No. 237, April, 88; No. 238, May, 70; No. 239, July, 88; No. 240, Sept., 70; No. 241, Oct., 64; No. 242, Dec., 94.
Nitric-Hydrofluoric Test
intergranular corrosion resistance
type 316 L stainless steel (Warren). Disc., No. 235, Jan., 44 (TP 14).
Nuclear Energy
fuel elements
aluminum alloys
long-range segregation of uranium (Peckner), No. 242, Dec., 51 (TP 211).
irradiation at high temperature
design problems (Stang, Goldthwaite, and Dunnington), No. 242, Dec., 54 (TP 214).
uranium slug and aluminum can
testing of unbonded areas by ultrasonics (Fouts), No. 242, Dec., 220 (TP 60).

O

Oils
demulsibility
high viscosity (Brennan), No. 242, Dec., 75 (TP 235).
lubricating
Wheeling steel method (Metzger), No. 242, Dec., 77 (TP 237).
Organic Coatings
thickness measurement
by infrared interferometry (Brightwell), No. 237, April, 67 (TP 87).

P

Petroleum
See Gasolines *and* Oils
Plaster
physical changes in setting
influence of gypsum crystals (O'Kelly), No. 237, April, 55 (TP 75) (*R*).
Plastics
capsules
for high-temperature irradiations (Stang, Goldthwaite, and Dunnington), No. 242, Dec., 54 (TP 214).
fiberglass, reinforced laminates
failure mechanisms (Desai and McGarry), No. 239, July, 76 (TP 156).
flexural modulus (Chambers and McGarry), No. 238, May, 38 (TP 106).
flexure properties
three-point test (Doyle and Olszewski), No. 241, Oct., 44 (TP 208).
polyethylene
control of thermal history of test specimens (Birks and Rudin), No. 242, Dec., 63 (TP 223).
Vicat softening point
modified testing apparatus (Ehlers), No. 236, Feb., 54 (TP 64). Disc., No. 241, Oct., 40 (TP 204).
See also Laminates *and* Resins
Polyethylene
test specimens
control method (Birks and Rudin), No. 242, Dec., 63 (TP 223).
Porosimetry
measurement of pore-size
by mercury penetration (Winslow and Shapiro), No. 236, Feb., 39 (TP 49) (*R*).
Powdered Materials
explosibility tester (Box), No. 241, Oct., 34 (TP 198) (*R*).

President's Address
impact of science on ASTM (Woods), No. 239, July, 9.
Proposed Method of Test
cement content of fresh concrete, No. 239, July, 48.
Proposed Specification
sealing compounds (polysulfides), No. 242, Dec., 146.
Publications
new ASTM publications, No. 235, Jan., 16; No. 236, Feb., 12; No. 237, April, 26; No. 238, May, 14; No. 239, July, 36; No. 240, Sept., 16; No. 242, Dec., 26.
ASTM publications in 1959–1960, No. 241, Oct., 5.

R

Railroads
research, report, No. 237, April, 31.
Random Samples
current materials news, No. 235, Jan., 30; No. 236, Feb., 61; No. 237, April, 81; No. 240, Sept., 61; No. 241, Oct., 47; No. 242, Dec., 83.
Refractories
for municipal incinerators
fluctuating temperature conditions (Engdahl and Sullivan), No. 240, Sept., 52 (TP 182).
Research
ASTM reports file, No. 241, Oct., 12.
cooperation on problems
ACR notes (Shobert), No. 239, July, 50.
cryogenic
for hydrogen bubble chambers (Birmingham, Chelton, Mann, and Hernandez) No. 240, Sept., 34 (TP 164) (*R*).
fatigue of metals (Dolan), No. 240, Sept., 24 (*R*).
fundamental and committee work (Harris), No. 238, May, 18.
highway construction (Armstrong), No. 241, Oct., 14.
materials needed in 1970. Report of AIA, No. 240, Sept., 28.
OTS reports, No. 235, Jan., 92; No. 236, Feb., 78; No. 237, April, 95; No. 238, May, 75; No. 239, July, 111; No. 240, Sept., 76, No. 241, Oct., 62; No. 242, Dec., 100.
railroads, No. 237, April, 31.
role in ASTM, ACR notes (Alden), No. 235, Jan., 25.
reports file, No. 241, Oct., 12.
Residual Stresses
in heat-exchanger tubes (Nelson), No. 240, Sept., 39 (TP 169).
Resins
tetrafluoroethylene
determination of crystallinity (McCrum), No. 242, Dec., 80 (TP 240).
See also Plastics
Resin-Glass
bond characteristics (McGarry), No. 235, Jan., 63 (TP 33).
Rubber
curing times
Mooney test (Juve), No. 239, July, 71 (TP 151).

S

Science Fairs
ACR notes (McPherson), No. 237, April, 29.
Sealants
for concrete joints
testing machine (Schutz and Van Hauter), No. 241, Oct., 42 (TP 206).
proposed specification
for building trade
polysulfides, No. 242, Dec., 146.
Silicones
for highway light reflectance (Cahn and Mackey, Jr.)., No. 235, Jan., 37 (TP 7). Disc., 41 (TP 11).
Slag
blast-furnace, portland cement
ignition loss (Chaiken), No. 238, May, 53 (TP 121).
Softening Point
plastics
modified Vicat type apparatus (Ehlers), No. 236, Feb., 54 (TP 64). Disc., No. 241, Oct., 40 (TP 204).
Soviet Russia
a new industrial threat (Ewell), No. 239, July, 43.
Standardization
actions on standards, No. 236, Feb., 14; No. 238, May, 15; No. 239, July 30; No. 240, Sept., 15; No. 241, Oct., 22; No. 242, Dec., 44.
building materials (Legget), No. 237, April, 36.
federal government standards changes, No. 235, Jan., 94; No. 236, Feb., 93; No. 237, April, 110; No. 238, May, 93; No. 239, July, 108; No. 240, Sept., 100; No. 241, Oct., 78; No. 242, Dec., 119.
in India (Pabst, Jr.) No. 242, Dec., 31.
instrument and laboratory apparatus (Ruh, Moran, and Thompson), No. 240 Sept., 31 (TP 161).
international (Townsend), No. 236, Feb., 15.
new Nickel oxide standards No. 238, May, 17.
new tentative and standards, No. 239, July, 30.
Statistics
application of (Speight), No. 236, Feb., 29 (TP 39).
theory of extreme values (Mandel), No. 236, Feb., 29 (TP 39) (*R*).
use of
in interlaboratory tests (Mandel and Lashof) No. 239, July, 53 (TP 133).
in materials specifications (Sheppard and Ginsburg), No. 236, Feb., 31 (TP 41).
Steel
notched alloy specimen
high-stress, low-cycle fatigue test (Yukawa and McMullin), No. 241, Oct., 38 (TP 202).
paint coatings (Copson and Larrabee), No. 242, Dec., 68 (TP 228).
stainless
corrosion resistance
nitric acid all-glass multiple-test apparatus (Tisinai and Samans), No. 238, May 64 (TP 132).
stainless-steel honeycombs (Gilbraith), No. 240, Sept., 51 (TP 181).
stainless type 316 L
nitric-hydrofluoric acid evaluation (Warren). Disc., No. 235, Jan., 44 (TP 14).
Strain Gages
checking device for indicators (Mills). Disc., No. 236, Feb., 47 (TP 57).
electrical resistance
false permanent strains (Newton), No. 235, Jan., 42 (TP 12). Disc., No. 239, July, 79 (TP 159).
Student Employment
promising trend in, ACR notes (Smith), No. 241, Oct., 21.
Sulfonates
alkyl aryl
determination by ultraviolet absorption (Kelley, Blank, Thompson, and Fine), No. 237, April, 70 (TP 90) (*R*).
Systems of Units
in instrument and laboratory apparatus (Ruh, Moran and Thompson), No. 240, Sept., 31 (T).

T

Technical Committee Notes, No. 235, Jan., 23; No. 236, Feb., 22; No. 237, April, 40; No. 238, May, 28; No. 239, July, 40; No. 240, Sept., 5; No. 241, Oct., 20; No. 242, Dec., 36.
"Teflon"
TEF-fluorocarbon resin determination of properties by crystallinity (McCrum), No. 242, Dec., 80 (TP 240).
Temperature Effect
on anelastic creep strain (Lubahn), No. 239, July, 61 (TP 141).
Tension Testing
high-speed tester (Strella), No. 236, Feb., 59 (TP 69).
metals
effect of specimen taper on elongation (Kula and Larson), No. 238, May, 58 (TP 126). Disc., No. 241, Oct., 37 (TP 201).
Testing Apparatus
plastics
Vicat softening point (Ehlers), No. 236, Feb., 54 (TP 64). Disc., No. 241, Oct., 40 (TP 204).
Testing Machines
abrader
for testing floor coverings (Gavan), No. 238, May, 44 (TP 112).
concrete joint sealants (Schutz and Van Hauter), No. 241, Oct., 42 (TP 206).
high-rate tension (Strella), No. 236, Feb., 59 (TP 69).
pore-size measurement (Winslow and Shapiro), No. 236, Feb., 39 (TP 49) (*R*).
physical parameters of metal
history (1837), No. 236, Feb., 26.
static and dynamic stresses
in high-temperature alloys (Hawkes and Ek), No. 235, Jan., 46 (TP 16). Disc., 51 (TP 21).
Testing Methods
interlaboratory evaluation (Mandel and Lashof), No. 239, July 53 (TP 133).
See also Cement, Coatings, Concrete, Fatigue, Flammability, Oils, Mortar, Plastics, Polyethylene, Rubber, Steel, Textiles, Timber, Ultrasonics, *and* Wall Panels.
Textiles
microstrains (Hamburger), No. 238, May 23.
thermal insulation
two methods (Wing and Monego), No. 241, Oct., 29 (TP 193).
Thermal Insulation
textiles (Wing and Monego), No. 241, Oct., 29 (TP 193).
Thermocouple Outputs
high-frequency response system (Tramposch, Papirno, and Girard), No. 238, May, 41 (TP 109).
Thermosetting Laminates
electrical resistivity
temperature dependence (Schlabach) No. 238, May, 33 (TP 101) (*R*).
Thickness Measurement
organic coatings
by infrared interferometry (Brightwell) No. 237, April, 67 (TP 87).
Three-Point Flexure Test
plastics (Dovle and Olszewski), No. 241, Oct., 44 (TP 208).
Timber
hardness test
improved and semiautomatic method (Schniewind), No. 236, Feb., 57 (TP 67).
Torsion Modulus
pendulum for measurement of crystallinity and void content in TFE resins (McCrum), No. 242, Dec., 80 (TP 240).

U

Ultrasonics
in testing irradiated fuel elements (Fouts), No. 242, Dec., 60 (TP 220).
Ultraviolet Absorption
for determination of alkyl aryl sulfonates (Kelley, Blank, Thompson, and Fine), No. 237, April, 70 (TP 90) (*R*).
Units of Measurement
problems in instrument and laboratory apparatus (Ruh, Moran, and Thompson), No. 240, Sept., 31 (TP 161).
Uranium
long-range segregation in aluminum alloys (Peckner), No. 242, Dec., 51 (TP 211).
slug and aluminum can in fuel elements
testing of unbonded areas by ultrasonics (Fouts), No. 242, Dec., 60 (TP 220).

V

Vicat Test
softening point of plastics
modified apparatus (Ehlers), No. 236, Feb., 54 (TP 64). Disc., No. 241, Oct., 40 (TP 204).

W

Wall Panels
fire endurance test
prediction of temperature rise (Neisel), No. 239, July, 66 (TP 146).
Water-Retardant Qualities
in external coatings (Soroka), No. 240, Sept., 40 (TP 170) (*R*).
Wet-Abrasion Resistance Test
for coating films (Diamond), No. 236, Feb., 48 (TP 58) (*R*).
Wood
See Timber
Writing, Technical (Walker), No. 240, Sept., 20; (Mowbray), No. 241, Oct., 18.

PROFESSIONAL CARDS

CARL BUSSOW
Consulting Chemist and Paving Engineer
Specialist on
Asphalt, Petroleum and Tar Products
801 Second Ave. New York 17, N. Y.

STILLWELL & GLADDING, INC.
Inspection-Sampling-ANALYSIS of Chemicals, Drugs, Fats, Greases, Oils, Waxes, Fertilizers, Glycerine, DDT., B.H.C., Chlordane, etc., Pyrethrum, Rotenone Products, Soaps, Solvents, Tests, AOAC., ASTM., NF., USP., Tobacco **Est. 1868**
130 Cedar Street New York 6, N. Y.

CROBAUGH LABORATORIES
Chemical & Metallurgical Analysts for
FOUNDRIES • METAL FINISHING • PROCESSING INDUSTRIES
★ Elevated temperature, tensile, and stress rupture testing
★ Leco oxygen determination
★ I. R. and U. V. Spectrophotometry
Since 1894
THE FRANK L. CROBAUGH CO.
3800 PERKINS AVENUE • CLEVELAND 14, OHIO

Container and Material Testing
THE DON L. QUINN COMPANY
224 West Kinzie Street
Chicago 10, Ill.
Independent tests, studies, surveys, and consultations
Member: ASTM, TAPPI, FPRS

INTERNATIONAL TESTING LABORATORIES, INC.
METALLURGISTS—CHEMISTS
CHEMICAL ENGINEERS
SPECTROGRAPHIC ANALYSIS
CHEMICAL AND PHYSICAL TESTING
METALS—ORES—PLASTICS—RUBBER—PAINTS
PAPER—FUEL.
METALLURGICAL INVESTIGATIONS
ENVIRONMENTAL TESTING
578-582 Market St., Newark 5, New Jersey

Jarrell—Ash
Spectrochemical Laboratory
Analysis—Research—Consulting
JARRELL-ASH COMPANY
26 Farwell St., Newtonville 60, Mass.
Tel: Decatur 2-2130

Testing Laboratories and Consultants
Write Advertising Dept.
ASTM Bulletin for
details on how your
card may appear here

DESERT SUNSHINE EXPOSURE TESTS
7740 N. 15th Ave.
Phoenix, Arizona
WE TEST ANYTHING UNDER THE SUN

Chicago Spectro Service Laboratory
Spectrographic and Chemical Analysts—Metallurgists
Quantometer (Direct Reading Spectrograph) for Metal Analysis
X-Ray Spectroscopy
2454 W. 38th St. Chicago 32, Ill.
Member: American Council of Independent Laboratories

ACADEMY TESTING LABORATORIES, INC.
ATL
Metallurgists—Chemists —Consultants
Specialists in Industrial Metallurgical Problems Cause of Failure Analyses
Hi & Lo Temperature Metallurgical Tests
350 W. 31 St., N. Y. 1, N. Y. S. A. Montanaro

COMMERCIAL LABORATORY FACILITIES
FOR NON-DESTRUCTIVE TEST • X-Ray (250 KVP) • Gamma Ray • Magnaflux • Brinell or Rockwell Hardness FOR STATIC TEST • 1,000,000 lbs. Universal Machine FOR DYNAMIC TEST • 9,000 lb. Drop Hammer FOR FATIGUE TEST • 60,000 lb. Life Test Machine FOR IMPACT TEST • Izod or Charpy Specimens (room or sub-zero temperatures) FOR STRESS ANALYSIS • Stresscoat • Strain Gauge Static & Dynamic Equipment
THE SYMINGTON-GOULD COMPANY
DIVISION OF SYMINGTON WAYNE CORPORATION
DEPEW, NEW YORK PHONE REgent 6000

COMPLETE LABORATORY SERVICE
• CHEMISTRY
• ELECTRONICS
• ENVIRONMENTS
• METALLURGY
• MICROBIOLOGY
• PHYSICAL TESTING
• PSYCHOMETRICS
• TEXTILE
• VIBRATION
UNITED STATES TESTING COMPANY, INC.
HOBOKEN, N. J.
BOSTON • BROWNSVILLE • DALLAS • DENVER
LOS ANGELES • MEMPHIS • PHILADELPHIA
PROVIDENCE • NEW YORK • TULSA

Johnson Soils Engineering Laboratory
Laboratory and Field Testing
Shear and Consolidation Tests
Design and Construction Control
MOBILE LABORATORIES
193 West Shore Avenue
Bogota, New Jersey

ESSEN & CO.
550: 8th Main Road., Bangalore-12
INDIA
SAMPLING • ANALYSIS
INSPECTION • ORES • MINERALS, etc.
Dr. N. Jayaraman., M.A., D.Sc., A.I.I.Sc., A.R.I.C., F.A.Sc.,
Director

TRUESDAIL Laboratories, Inc.
CHEMISTS ENGINEERS BACTERIOLOGISTS
4101 N. Figueroa
Los Angeles 65, Calif.
CA 5-4148
San Francisco
Terminal Island
Honolulu
Member: American Council of Independent Laboratories

Reinforced Plastics PRinceton 1-3200
ctl
CTL, Inc.
Low and high temperature mechanical, electrical and chemical testing.
P. O. BOX 227 CINCINNATI 15, OHIO

RESEARCH
DEVELOPMENT
QUALITY CONTROL
DTL
554 BAGLEY
PHONE WO 1-4870
DETROIT 26, MICH.
THE DETROIT TESTING LABORATORY, INC.
Member: American Council of Independent Laboratories

ARIZONA TESTING LABORATORIES
Chemists—Assayers—Engineers
Chemical & Spectrographic Analysis
Physical Tests—Inspection
Soil Investigation—Sampling
Outdoor Weathering Tests
817 W. Madison, Phoenix, Arizona
Member: American Council of Independent Laboratories

"FIRST IN FASTENER RESEARCH"
A
Static-Fatigue-Vibration
Salt Spray-Elevated Temperature Testing
Metallurgical Laboratory
Research & Consultation
ALMAY RESEARCH & TESTING CORP.
3510 E. 14th St., AN 8-3546, Los Angeles 23, Cal.

Cable "Sayboltoil" All Standard Codes—Specify
TANK STRAPPING
E. W. SAYBOLT & CO., INC.
INSPECTORS OF PETROLEUM
Licensed by New York Produce Exchange
265 Bayway, Elizabeth 2, N. J.
Dependable Inspection Service at All Points
Bulk Cargo Inspection Our Specialty
Laboratories and Offices in Important cities

Testing Laboratories and Consultants
Write Advertising Dept.
ASTM BULLETIN for
details on how your
card may appear here.

Tel. HI 2-3469

CORMET METALLURGICAL LABORATORY

P. O. BOX 231 FORDS, N. J.

HAROLD C. SCHANCK, JR.
Director

PELMOR LABORATORIES INC.

TESTING — RESEARCH
DEVELOPMENT — CONSULTING
BASIC MATERIALS TO END PRODUCTS
RUBBER, PLASTICS, ELASTOMERS, SILICONES
COMPOUNDING, FORMULATION
ANALYSIS, MOLD DESIGN
PROCESSING & METHODS

401 Lafayette St. Newtown, Pa.

CHARLES C. KAWIN COMPANY

METALLURGICAL CHEMISTS
FOUNDRY and METALLURGICAL ENGINEERS
METALLOGRAPHERS—SPECTROGRAPHERS
PHYSICAL TESTS

431 S. Dearborn St. Chicago 5, Ill.
P.O. Box 2035 Buffalo 5, N. Y.

Member: American Council of Independent Laboratories

COMMERCIAL TESTING & ENGINEERING CO.

CHEMISTS, ENGINEERS & INSPECTORS
COAL—COKE—IRON ORE
PETROLEUM PRODUCTS—MINERALS

228 N. LaSalle St., Chicago 1, Ill.
Charleston, W. Va. Norfolk, Va. Cleveland, O.
Clarksburg, W. Va. Terre Haute, Ind. Toledo, O.
Madisonville, Ky. Steubenville, Pa.

TEXTOR LABORATORY DIVISION, Cleveland, O.
COMMERCIAL TESTING CO., INC., Buffalo, N. Y.

Member: American Council of Independent Laboratories

CYRUS WM. RICE & COMPANY

. . . ESTABLISHED 1916 . . .

15 NOBLE AVENUE, PITTSBURGH 5, PA.

INDUSTRIAL WATER CONSULTANTS

PATZIG TESTING LABORATORIES

ENGINEERING INSPECTION
TESTS • ANALYSIS • RESEARCH
—OF—
EQUIPMENT • APPLIANCES
MATERIALS & PRODUCTS

Ingersoll Ave. & 23rd St. Des Moines, Iowa

Member: American Council of Independent Laboratories

The Oldest Commercial Laboratory In America

BOOTH, GARRETT & BLAIR

Established 1836

Analytical and Consulting Chemists
Samplers and Weighers

228 South Ninth Street Philadelphia 7, Pa.

Omaha Testing Laboratories

Chemists, Testing and Inspection Engineers

Testing, Inspection, Consultation, Design of all types of building and paving materials.

Investigation of Foundation Soils

511 South 20th St. Omaha 2, Nebraska

PENNIMAN & BROWNE, INC.

CHEMICAL & PHYSICAL TESTING-RESEARCH
Soils Investigation—Field X-Ray
Concrete Design & Control—Steel Inspection
COAL SAMPLING AND ANALYSIS
Philadelphia—Baltimore—Hampton Rds.
Member: American Council of Independent Laboratories, Inc.
6252 Falls Road, Baltimore 9, Md.

JOSEPH S. WARD, INC.

SOIL TESTING LABORATORY

Identification and Strength Tests on Soils, Field Supervision, Reports, Consultation.

91 Roseland Avenue
Caldwell, N. J.
Tel. Capital 6-9191

Water Service Laboratories, Inc.

Specialists
in
Water Treatment

Main Office: 15 W. 131 St., N. Y. 27, N. Y.

NEW YORK TESTING LABORATORIES, Inc.

47 West St., New York 6, N. Y.—Bowling Green 9-6220-9

SERVING INDUSTRY SINCE 1919

Complete facilities for:
- Electrical, Electronic, Environmental, X-Ray Testing.
- Chemical, Metallurgical, and Physical Testing.
- Expert Court Testimony.
- Engineering.
- Production Evaluation.

Write for our Free Facilities Brochure.

PORE SIZE DETERMINATIONS

Complete pore spectra by mercury intrusion, 1000 to 0.1 micron diameter. All materials: ceramics, metals, plastics, carbon. Filters, catalyst carriers, structural materials, electrodes, separators, etc.

PRADO LABORATORIES
P. O. Box 2607 Cleveland 7, Ohio
Write for explanatory literature.

Europe

KONING & BIENFAIT

Testing Laboratories of Building Materials
Consulting Engineers — Metallurgists —Chemists
Inspection — Sampling — Testing — Analysis
Research — Development — Control

Coal, Oils, Fats, Waxes, Cement, Concrete, Steel, Water, Gases, Solvents, Paints, Ores. Established 1890

104 Dacostakade. Amsterdam-W. P.O. Box 6005

NSL *Research and Development*

NATIONAL SPECTROGRAPHIC LABORATORIES, INC.

Chemists, Physicists, Engineers, Inspectors, Complete Analytical laboratories: quality control, research and development—Metallurgy, ceramics, nuclear fuels, radiochemistry, industrial hygiene, health physics, organics, minerology, agriculture, food, medicine.

6300 Euclid Ave., Cleveland, Ohio Utah 1-4664
1180 Palm Ave., Hialeah, Fla. Tuxedo 5-1691

SOUTHWESTERN LABORATORIES

since 1912
Consulting, Analytical Chemists
and Testing Engineers
Inspection, Testing, Chemical, Foundation
Soils, Environmental, Metallographic and
Radiographic Work

Fort Worth, Dallas, Houston, Beaumont and Midland, Texas

Member: American Council of Independent Laboratories

ELECTRICAL TESTING LABORATORIES, INC.

2 East End Avenue, New York 21, N.Y.

Electrical, Electronic, Environmental, Photometric and Chemical Laboratories, Testing, Research, Inspection and Certification

---

BOWSER-MORNER

TESTING LABORATORIES, INC.

Chemists—Engineers—Inspectors

Spectrographic and Chemical Analysts—
Concrete Design & Control—Soils Investigation
Environmental Testing

P.O. Box 51 Dayton 1, Ohio

Member: American Council of Independent Laboratories

Herron Testing Laboratories, Inc.

Analysis — Testing — Inspection

Chemical Physical
Radiographic Metallurgical

Subsoil Evaluation — Concrete Control

1360 W. 3rd Street, Cleveland 13, Ohio
122 Clinton Street, Buffalo 3, N. Y.

Member: American Council of Independent Laboratories

Seelye Stevenson Value & Knecht

Consulting Engineers

Richard E. Dougherty, Consultant

Airports, Highways, Bridges, Dams, Water Supply, Sanitation, Tunnels, Piers, Industrial Plants, Reinforced Concrete, Steel, Industrial Waste Disposal, Foundations, Soil Studies.

CIVIL — MECHANICAL — ELECTRICAL

101 Park Avenue New York 17, N. Y.

PITTSBURGH TESTING LABORATORY

Testing—Inspection—Analysis
Radiography—Soils Mechanics

Main Office Pittsburgh, Pa.

32 Laboratories in Principal Cities

THE H. C. NUTTING COMPANY

Testing Engineers—Inspection Service
Foundation Investigation—Test Borings
Soil Mechanics—Sewage Flows—Analysis
Construction Control—Soil—Concrete
Bituminous Pavements—Water Waste Survey
Specifications—Consultants

4120 Airport Road Cincinnati 26, Ohio

ST. LOUIS TESTING LABORATORIES

2317 CHOUTEAU AVE. ST. LOUIS 3 MO.

CHEMICAL, PHYSICAL, METALLURGICAL
TESTING AND INSPECTION OF MATERIALS
X-RAY AND GAMMA RADIOGRAPHY

C. D. TROWBRIDGE
DIRECTOR

Central 1-8080

Member—American Council of Independent Laboratories

The Haller Testing Laboratories, Inc.

140 Cedar Street, New York 6, N. Y.

Testing—Inspection—Consultation
Concrete—Asphalt—Steel
Soil Borings—Soils Laboratory

New York Boston, Mass.
Plainfield, N. J. New Haven, Conn.

LEHIGH TESTING LABORATORIES

P. O. BOX 1241, WILMINGTON, DEL.

Analysis
Research
Development
Investigations

Spectrography
Physical Testing
Salt Spray
Radiography

SOIL TESTING SERVICES, INC.

Soil Investigations
Laboratory Testing
Engineering Reports & Recommendations

1827 North Harlem Avenue, Chicago 35, Illinois
Milwaukee: Portland, Michigan
San Francisco: Kenilworth, New Jersey: Havana, Cuba

SHILSTONE TESTING LABORATORY

Chemists & Engineers

Spectrographic Analyses*

New Orleans, La. *Houston, Tex.

Inspection at all leading industrial centers

Member: American Council of Independent Laboratories

ABBOT A. HANKS, Inc.
Established 1866

Engineers—Chemists—Assayers—Samplers
Spectrographers;
Inspection—Tests—Consultation—Research

Member: American Council of Independent Laboratories
1300 Sansome Street, San Francisco 11, California
EXbrook 7-2464

MILLION VOLT X-RAY SERVICE

also

Low Voltage X-ray, Gamma-ray Magnaflux, Zyglo, Ultrasonics, Impact, Chemical, Metallography, Physical, Hardness, Stress Rupture, Spectrochemical Tests.
Laboratory and Field Testing and Inspection.

ARNOLD GREENE TESTING LABORATORIES Inc.
Oak Street • East Natick Industrial Park
East Natick, Massachusetts • CEdar 5-7330

SUB-TROPICAL TESTING SERVICE, INC.

since 1929

Originators of public weather-testing service for paints, plastics, fabrics, etc.
Marine testing . . .
Free literature
Member: ASTM, ACS, FPVPC.

only true tropical zone in USA.

8290 S.W. 120th Street
Miami 43, Florida

WALTER H. FLOOD & CO.
Consulting Chemical Engineers

TESTING AND INSPECTION
OF MATERIALS
CONCRETE CORING
SOIL BORING

6192 South Blackstone Ave.
Hyde Park 3-1512
CHICAGO, ILLINOIS

SOUTHERN LABORATORIES, INC.
Engineers—Chemists

Sub Soil Investigations
Physical, Chemical, and Soil Laboratories
Research & Inspection
Complete Model Shop

P. O. Box 346
Mobile, Alabama

P. O. Box 10,096
New Orleans, La.

ROBERT W. HUNT COMPANY ENGINEERS

Inspection, Tests, Consultation, Research

CHEMICAL, PHYSICAL, TEXTILE, METALLURGICAL, CEMENT and CONCRETE LABORATORIES

810 S. Clinton St., CHICAGO 7, *All Large Cities*

South Florida Test Service, Inc.

Testing • Research • Engineers

Consultants and specialists in corrosion, weathering and sunlight testing.

4301 N. W. 7th Street
Miami 44, Fla.

Established 1931

Member: American Council of Independent Laboratories

PHOENIX CHEMICAL LABORATORY, INC.

Fuel and Lubricant Technologists
Analysis Research Development
3953 West Shakespeare Avenue
Chicago 47, Illinois
Telephone: SPaulding 2-3577

LUCIUS PITKIN, INC.
ESTABLISHED 1885

Metallurgical Chemists & Consultants
Chemical Analysis, Fire Assays
X-Ray & Emission Spectrographic Analysis
Metallography, Testing, Research

47 FULTON ST. NEW YORK 38, N. Y.
Member: American Council of Independent Laboratories

YARSLEY TESTING LABORATORIES LIMITED

Founder: DR. V. E. YARSLEY—in practice since 1931

INSPECTION, TESTING, ANALYSIS
in Great Britain and Europe of
Plastics, Rubbers, Adhesives, Wood, Plywood Board, Insulation, Ceramics, Glass, etc., etc.
OFFICIALLY APPROVED TEST HOUSE
Clayton Road, Chessington, Surrey, ENGLAND

CHEMICAL & ENGINEERING CONSULTANTS

Research, process and product development, plant design, nuclear and surface chemistry, analyses, bacteriology, toxicology, organic syntheses, market surveys.

SNELL FOSTER D. SNELL, INC.
29 W. 15th St., N.Y. 11, N.Y.
Telephone: WAtkins 4-8800

Member: American Council of Independent Laboratories

TOLEDO TESTING LABORATORY

Engineers — Chemists — Geologists
Concrete — Soils — Asphalt
Inspection — Tests — Research
Soil Test Borings — Diamond Drilling
Soils Mechanics Laboratory

1810 North 12th St., Toledo 2, O.

WARNER LABORATORIES
Cresson, Pa.

Coal Analysis—Sampling—Washability
In the Heart of Bituminous Production
Also Clay—Lime—Limestone
Mineral Fillers—Water

Established 1923 Member: A.C.I.L.

LEDOUX & COMPANY, INC.

Chemists, Assayers, Engineers
Samplers and Weighers
Spectroscopists

359 ALFRED AVENUE
TEANECK, NEW JERSEY

Member: American Council of Independent Laboratories

A. W. WILLIAMS INSPECTION, CO., INC.
MOBILE, ALABAMA
Established 1921

Chemical and Physical Laboratories
Inspections—Tests—Analyses—Sampling
Radiographic—Sub-Surface Exploration
Representatives Throughout U.S.A.
Member: American Council of Independent Laboratories

W. B. COLEMAN & CO.

Metallurgists-Chemists-Engineers

Spectrographic Analysis
Chemical and Physical Testing
Metallurgical Investigations
Boiler Water Conditioning
Consultation Service

9th & Rising Sun Ave., Philadelphia 40, Pa.
Member: American Council of Independent Laboratories

A COMPLETE TESTING SERVICE

Environmental
Vibration
Radio Interference
Electronics

QUALITY CONTROLLED YORK RESEARCH CORPORATION

Mechanical
Market Research
Quality Control
Non-Food Product Testing

YORK RESEARCH CORP.—STAMFORD, CONN.

THE MOST EXPERIENCED
FILM BADGE SERVICE
ST. JOHN X-RAY LABORATORY
CALIFON, NEW JERSEY
Established 1925

SMITH-EMERY COMPANY

Chemists — Engineers

Sampling, Analyzing, Assaying
Spectrography, Physical Testing

Member: American Council of Independent Laboratories

781 E. Washington Blvd. Los Angeles 21, Calif.

Construction Materials
& Structural Systems
Testing Development
& Research

THE THOMPSON & LICHTNER CO., Inc.
8 Alton Place, Brookline, Mass.

GRAHAM, SAVAGE & ASSOCIATES, Inc.

Consulting—Engineering—Research

Electroplating and Metal Processing
Waste Treatment and Production Problems
Surveys—Designs—Specifications

475 York Rd. Jenkintown, Pa.
1724 Clinton St., Kalamazoo, Mich.

Radiographs-

dry and ready-to-read in 13 minutes

KODAK INDUSTRIAL X-OMAT PROCESSOR

Now it takes only 13 minutes to process your industrial radiographs. The Kodak X-Omat Processor produces radiographs of uniform high quality . . . and it brings automation to your darkroom.

Exposed films are merely removed from their holders and fed directly into the processor. Film hangers are eliminated. And only 22 inches of the unit's 10-foot, 10-inch length need extend into the darkroom itself.

Kodak Industrial X-ray Films, Type AA and Type M—sheet films or continuous lengths—go through the system at the rate of 38 inches per minute.

This means time saved and costs cut. You should have the complete story. Send for the folder that gives all the details.

X-ray Division — EASTMAN KODAK COMPANY — Rochester 4, N.Y.

EASTMAN KODAK COMPANY, X-ray Division, Rochester 4, N. Y. 43-12

☐ Send the folder about the Kodak Industrial X-Omat Processor.

☐ Send the names of the Kodak Industrial X-Omat Processor dealers in my area.

Name _____

Firm Name _____

Firm Address (Street) _____

(City) _____ (Zone) _____ (State) _____

Mail this coupon for full information

Kodak
TRADE MARK

FOR FURTHER INFORMATION CIRCLE 389 ON READER SERVICE CARD

NEW MEMBERS...

The following 148 members were elected from September 10 to November 6, 1959, making the total membership 10,041 ... Welcome to ASTM

Note—Names are arranged alphabetically—Company members first then individuals—
Your ASTM Year Book shows the areas covered by the respective Districts.

Central New York District

New York State Department of Public Works, district engineer, 109 N. Genesee St., Utica 1, N. Y.

Chicago District

Industrial Rubber Goods Co., A. G. Storms, sales representative, 14 Kamber Rd., St. Joseph, Mich.

National Association of Architectural Metal Manufacturers, J. M. Roehm, chairman, Research and Development Committee, 228 N. LaSalle St., Chicago 1, Ill.

Alvestad, Ralph N., chief estimator, Gethmann Construction Co., Inc., Box 456, Gladbrook, Iowa.

Broos, Robert W., laboratory supervisor, H. B. Fuller Co., 255 Eagle St., St. Paul 2, Minn.

Davis, J. William, test engineer, Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul, Minn. For mail: 1210 University Ave., St. Paul, Minn.

Davis, Louis D., Jr., test engineer, American Steel Foundries, Hohman and Hoffman Sts., Hammond, Ind.

Douglas, David, David Douglas and Co., Inc., 1332 S. 26th St., Manitowoc, Wis.

Krueger, T. W., chemist, Touchdown Div., Redson-Rice Corp., 1111 W. Winona Ave., Chicago 40, Ill.

Kuenning, William H., senior development engineer, Portland Cement Assn., 5420 Old Orchard Rd., Skokie, Ill.

* [A] denotes Associate Member.

Motivala, Meherwan B., assistant application engineer, Claud S. Gordon Co., 3000 S. Wallace St., Chicago 16, Ill. [A*]

Phares, E. K., superintendent, S. G. Taylor Chain Co., Inc. 1 141st St., Hammond, Ind.

Rieman, Willis E., engineer, The Gudeman Co., 340 W. Huron St., Chicago 10, Ill. [A]

Stowell, Finch, director, Chicago Div., Container Laboratories, Inc., 112 W. Kinzie St., Chicago 10, Ill.

Vance, Glenn, president, Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.

Vickers, Stanley James, chief engineer, American Forge Div., American Brake Shoe Co., 1220 W. 119th St., Chicago 43, Ill. For mail: 12846 S. 82nd Court, Palos Park, Ill.

Williams, R. F., specifications and standards engineer, Whirlpool Corp., St. Paul Div., St. Paul 6, Minn.

Cleveland District

Ohio Turnpike Commission, Maintenance Dept., 682 Prospect St., Berea, Ohio.

Burgess, Woodrow L., assistant director of engineering, The Master Builders Co., 7016 Euclid Ave., Cleveland 3, Ohio.

Feichter, Harold Richard, director of research, United States Ceramic Tile Co., 217 Fourth St., N. E., Canton 2, Ohio.

Peterson, H. P., municipal consultant, 5250 Northfield Rd., Maple Heights 37, Ohio.

Roberts, John T., research engineer, Ingersoll-Humphryes Div., The Borg-Warner Corp., 201 E. Fifth, Mansfield, Ohio. For mail: 1156 Briarwood Rd., Mansfield, Ohio.

Detroit District

Funston, Robert, chief chemist, Quality Control, Wyandotte Chemicals Corp., Wyandotte, Mich.

Kroliklewicz, Max, test and development engineer, Chrysler Corp., Missile Div., Box 2628, Dept. 7644, Detroit 31, Mich. [A]

Oberdick, Willard A., associate professor of architecture, College of Architecture and Design, Univ. of Michigan, Ann Arbor, Mich.

New England District

General Findings and Supply Co., J. E. Doescher, chief product engineer, Industrial Div., Attleboro, Mass.

Instrument Development Laboratories, Inc., Donald R. Hall, marketing manager, Photometric Products, 67 Mechanic St., Attleboro, Mass.

Shawiningan Resins Corp., Herbert Terry, group leader, Box 2130, Springfield 1, Mass.

Emery, Jackson K., vice-president, research, The Van Keuren Co., 176 Waltham St., Watertown, Mass.

Kratzert, Arthur W. C., chief engineer, The Brunalli Construction Co., 109 Summer St. Southington, Conn.

Lathrop, Robert P., chief engineer, testing accessories, Baldwin-Lima-Hamilton Corp., Electronics and Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.

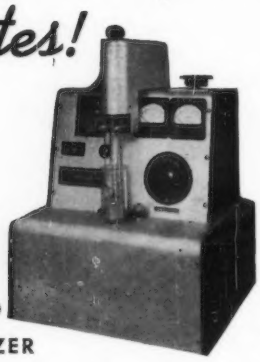
Malo, Urbain J. H., technical director, Narragansett Wire Co., 541 Pawtucket Ave., Pawtucket, R. I.

Mitchell, Neal B., Jr., instructor, Tufts Univ., Medford 55, Mass. For mail: 28 Capen St., Medford, Mass. [A]

Shaw, Robert E., engineer, in charge of circuit breakers, Sylvania Electric Products, Inc., Estes St., Ipswich, Mass.

Weiss, Richard S., vice-president, Avica Corp., Box 180, Newport, R. I.

Coppen Assay in 8 Minutes!



Eberbach
ULTRA-SPEED
ELECTRO-ANALYZER

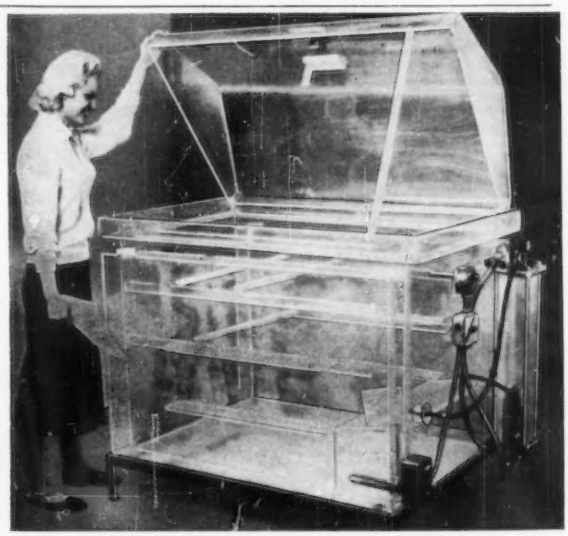
Equals production rate of 4 positions on conventional apparatus. For example, in a copper assay, an analytically complete deposition of a one gram sample is accomplished in 8 minutes. Best equipment and techniques previously employed require 30 to 60 minutes.

Request Bulletin 390-V

Eberbach
CORPORATION

P.O. Box 63 Ann Arbor, Michigan

CIRCLE 390 ON READER SERVICE CARD



G-S CORROSION TEST CABINETS

★ Salt Fog
★ Acetic Acid
★ Humidity
★ Corrodkote
★ Cass Tests

Highest Uniform Accuracy of Test Results. Over-all Visibility at Lower Cost!

Preferred by those who set the standards. Meet A.S.T.M. and Gov't Specifications. All-welded H-T Lucite, also lined Steel or lined Stainless—sizes, types to suit. Send for new Bulletin, prices. Manufactured exclusively by The Singleton Co.

THE G. S. EQUIPMENT CO.
15579 Brookpark Rd., Cleveland 35, Ohio, Phone: CL 2-477

CIRCLE 391 ON READER SERVICE CARD

New Members

New York District

Hydromatics, Inc., H. J. Britton, chief engineer, 70 Okner Pkwy., Livingston, N. J.

Industrial Raw Materials Corp., A. Aufhauser, president, 575 Madison Ave., New York 22, N. Y.

Jacob Brothers, Inc., Robert Jacob, president, 1240 Seaview Ave., Bridgeport 7, Conn.

Pawling Rubber Corp., Herbert F. Kleinhans, manager, product development, Pawling, N. Y.

Anderson, Robert L., civil engineer, Sidney B. Bowns and Son, 161 Willis Ave., Mineola, N. Y. For mail: 75 Balsam Lane, Levittown, N. Y.

Bahret, Edward G., industrial sales engineer, De Laval Separator Co., 25 Columbia St., Poughkeepsie, N. Y.

Carr, Donald R., vice-president, Isotopes, Inc., 123 Woodland Ave., Westwood, N. J.

Dohrmann, Henry C., vice-president, engineering, Buell Engineering Co., Inc., 123 William St., New York 38, N. Y.

Foster, Dean, vice-president, research and development, M and M's Candies, Hackettstown, N. J.

Hanington, Robert A., town engineer, Town of Babylon, 200 E. Sunrise Hwy., Babylon, N. Y. For mail: 206 Mayhew Ave., Babylon, N. Y.

Haugen, Lee, vice-president, Cities Service Research and Development Co., 60 Wall Tower, New York 5, N. Y.

Hibner, Michael, chemical engineer, Hibner and Co., 691 W. Prospect Ave., Fairview, N. J.

Hooper, William K., vice-president, Republic Foil, Inc., 55 Triangle St., Danbury, Conn.

Irthum, H. J., manager, filtration new design, Dorr-Oliver, Inc., Havemeyer Lane, Stamford, Conn.

Kingshott, John H., field engineer and inspector, Madigan-Hyland, 28-04 41st. Ave., Long Island City 1, N. Y. For mail: 84 Norwood Ave., Staten Island 4, N. Y.

Kuhn, William G., assistant chief metallurgist, Norma-Hoffmann Bearings Corp., Hamilton Ave., Stamford, Conn.

Longhi, Edward J., president, Westchester Testing Co., Inc., 34 Weyman Ave., New Rochelle, N. J.

Manypenny, Gerry O., editor *Food and Drug Packaging*, 660 Madison Ave., New York 21, N. Y.

Mohsen, Adel, instructor, Newark College of Engineering, 365-369 High St., Newark 2, N. J.

Parish, Roger H., vice-president, Routh Coal Export Corp., subsidiary of The Pittston Co., 250 Park Ave., New York 17, N. Y. For mail: 55 Pinecliff Rd., Chappaqua, N. Y.

Pearson, Warner M., architect, 241 Sunrise Hwy., Rockville Centre, N. Y.

Riley, Robert S., chief engineer, Engineered Plastics, Inc., P. O. Drawer P, Watertown, Conn.

Rosenberg, William W., chief of subcontractor and materials, New York City Housing Authority, 299 Broadway, New York 7, N. Y. For mail: 54 Richfield St., Plainview, L. I., N. Y.

Stern, Theodore L., engineer, C. S. Brainin Co., 320 Washington St., Mt. Vernon, N. Y.

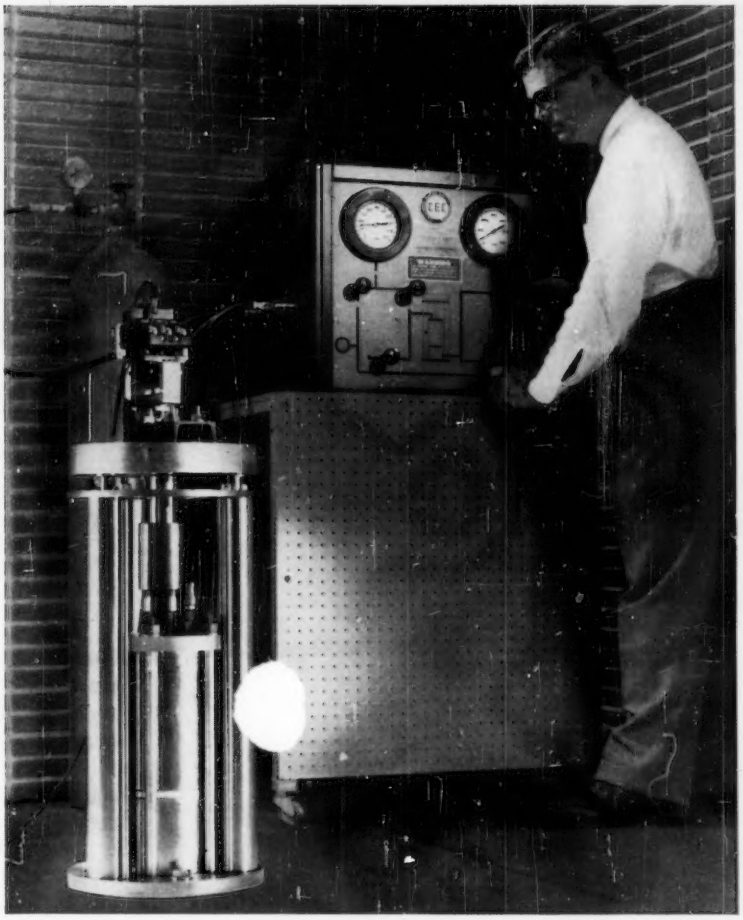
Vilella, Mario, vice-president, research, Electro-Thermal Industries, Inc., 57 S. Main St., Pearl River, N. Y. For mail: 115 Warren Rd., Park Ridge, N. J.

Northern California District

Barneyback, Robert S., Jr., ready-mixed concrete technician and salesman, Kaiser Sand and Gravel, 1924 Broadway, Oakland 12, Calif. For mail: 500 Fifth Ave., Oakland 6, Calif. [A]

Breuer, Frederick W., section head, plastics, Richmond Research Laboratory, Stauffer Chemical Co., 1375 S. 47th St., Richmond 4, Calif.

(*Continued on page 98*)



New Hyge slashes cost of production-line *shock* tests

COSTS LESS, TESTS MORE
This new Hyge Shock Tester gives you two most widely specified shock pulses: 11 ± 1 ms ½ Sine, and 6 ± .5 ms Sawtooth . . . yet costs less than single-test units!

5 SHOTS IN 5 MINUTES, 5¢ APIECE
Low-cost bottled nitrogen powers the fast cycle . . . ready for the next shot in less than a minute!

EXCLUSIVE! FAST, EXTERNAL CHANGE OF WAVEFORM
Only this new Hyge changes waveform and thrust level without disassembly in a matter of minutes.

WIDEST TEST RANGE
From gram-weight components up to bulky 150-pound objects. Maximum acceleration 100G. Capacity: 15000 pounds specimen thrust.

COMPACT, CAN BE BUILT INTO PRODUCTION LINE
Height: 29¼". Base: 13" square.

Write for new Hyge Bulletin 4-71.

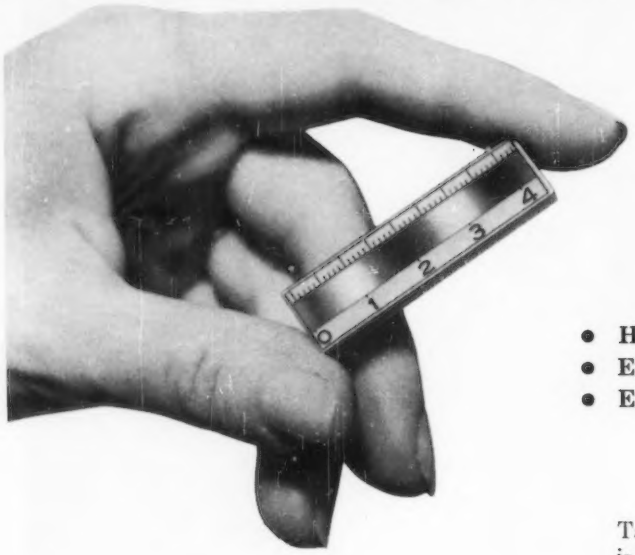
Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

A SUBSIDIARY OF CONSOLIDATED ELECTRODYNAMICS CORPORATION
(FORMERLY ROCHESTER DIVISION)

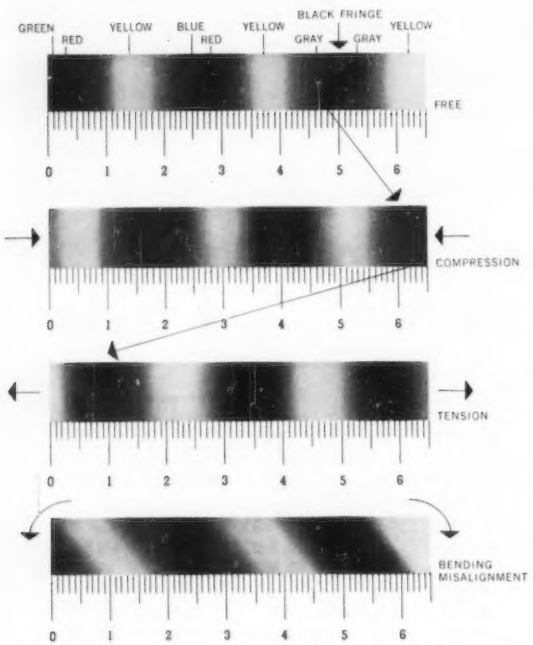
FOR FURTHER INFORMATION CIRCLE 392 ON READER SERVICE CARD

Two versatile new Tatnall



1 Direct-reading PhotoStress Gage

- **High sensitivity, instant response**
- **Easy to bond to almost any material**
- **Exceptionally rugged and stable**



Tatnall Measuring Systems' new PhotoStress Gage is a completely self-contained strain measuring instrument requiring no external meters. Calibrated in pounds, inch-lb., psi or similar units, it gives direct visual reading of many types of loads . . . also shows misalignment. Unaffected by humidity, easily applied to metals, wood, concrete, plastics, and almost any other material, it is a versatile, accurate tool for stress investigations on actual structures and parts.

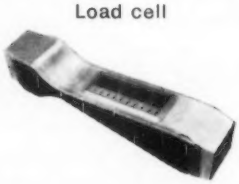
The PhotoStress Gage is a small rectangular piece of plastic mirrored on one side and covered with a polarizing material on the other, and incorporates a numbered scale. Contrasting color fringes are always visible along the gage's length, as shown. When strain is applied along the axis of the gage, the color fringes shift to a new position. Fringe displacement is proportionate to strain, which is read directly from the gage's calibrated scale. Sensitivity is within 20 or 40 microinches per inch, depending on the type of gage. Dynamic measurements can be made with a strobe light.

Write or call for complete information.

A few basic applications of the new Tatnall PhotoStress Gage

Strain gage

Load cell



Pressure Gage

Torque indicator

FOR FURTHER INFORMATION CIRCLE 393 ON READER SERVICE CARD

Gages from Bud

2

MetalFilm 102
High-temperature Strain Gage

- **Operating range to over 400°F**
- **Extremely accurate, repeatable and conformable**
- **Maximum dimensional stability and fatigue life**

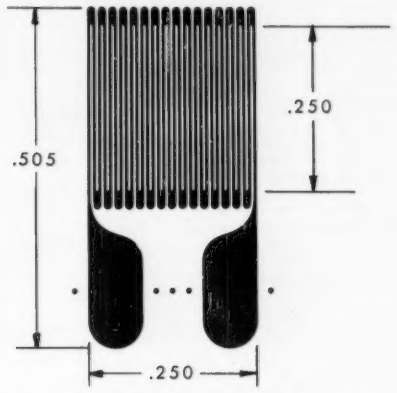
New MetalFilm 102 strain gages surpass the temperature limits of previous gages by at least 50°F in all applications. Temperature range is actually not limited by the gage itself, which can operate to at least 500°F, but by the 430-450°F melting point of high-temperature solders presently available for gage connections.

Key to the exceptional high-temperature performance of MetalFilm 102 gages is a new backing material—a phenolic-epoxy blend—developed by Tatnall Division. This material helps MetalFilm 102 gages exhibit far less creep, hysteresis and sensitivity loss than phenolic type gages. The new gages are temperature-compensated, flexible and ultra-thin (less than 0.0015 inches thick), with no integral leads that reduce conformability and fatigue life. They are quickly applied with the new high-temperature epoxy cements, and require low clamping pressure.

All the advantages of the MetalFilm manufacturing technique are inherent in the new gages. Their high uniformity, in both geometry and temperature coefficient, makes matching automatic. A wide range of sizes and configurations is available.

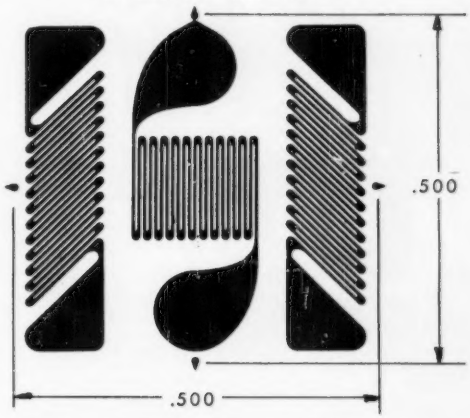
Write or call for complete information.

Typical MetalFilm 102 gages
(Backing area not shown)



Standard configuration for static and dynamic strain measurements

Miniature gage for fillets and other areas that have steep strain gradients



Rosette type employing three-gage 45° rectangular geometry for determining magnitude and direction of principal strains

TATNALL MEASURING SYSTEMS DIVISION

THE Bud COMPANY

P.O. BOX 245
PHOENIXVILLE, PENNSYLVANIA

In Canada—Tatnall Measuring and Nuclear Systems, Ltd.
46 Hollinger Rd.
Toronto 16, Ont.

New Members

(*Continued from page 95*)

Kettering, Russel D., manager of technical service, Oliver Tire and Rubber Co., 1256 65th St., Oakland 8, Calif.

U. S. Naval Ammunition Depot, John H. Cusick, head, Physical Science Div., Quality Evaluation Laboratory, Concord, Calif.

Wheeler, Grant M., supervisor, Tidewater Oil Co., Box 137, Associated, Calif.

Ohio Valley District

Echstenkamper, William L., executive director and chief engineer, The Plantmix Asphalt Industry of Kentucky, Inc., New Capital Hotel, Frankford, Ky. For mail: Box 286, Frankford, Ky.

Haines, Harvey H., packaging engineer, The Champion Paper and Fibre Co., 601 N. "B" St., Hamilton, Ohio.

Maurer, John L., supervisor, chemical and metallurgical engineering, Transmission and Chassis Div., Ford Motor Co., 3000 Sharon Rd., Sharonville, Ohio.

Philadelphia District

Pennsylvania Military College, Leo Blumberg, director of engineering, 14th and Chestnut Sts., Chester, Pa.

Selby, Battersby and Co., C. S. Cook, vice-president, 5220 Whitby Ave., Philadelphia 43, Pa.

Altier, William J., assistant manager, Engineering Dept., Reeves-Hoffman Div., Cherry & North Sts., Carlisle, Pa.

Black, Marion L., Test Dept., The Budd Co., 2450 W. Hunting Park Ave., Philadelphia 32, Pa. For mail: 2057 Pleasant Ave., Glenside, Pa.

Eisenhauer, F. S., director of specifications, J. T. Baker Chemical Co., 500 Broad St., Phillipsburg, N. J.

Kibbel, William H., Jr., manager, inorganic application, Food Machinery and Chemical Corp., Box 8, Princeton, N. J. For mail: Box 44, Dublin Rd., R. D. 1, Pennington, N. J.

Neave Robert B., standards engineer, Philadelphia Gas Works, division of United Gas Improvement Co., 1401 Arch St., Philadelphia 5, Pa. For mail: 1800 N. Ninth St., Philadelphia 22, Pa.

Saibel, Mahlon R., senior consultant, Kurt Salmon Associates, 3000 Albemarle St., Washington 8, D. C. For mail: 444 Covered Bridge Rd., Haddonfield, N. J.

Pittsburgh District

de Supinski, Bronis, development manager, Marbon Chemical Div., Borg-Warner Corp., Box 68, Washington, W. Va. For mail: 27 Willowbrook Dr., Parkersburg, W. Va.

Gwin, Lewis L., president, Gwin Engineers, Inc., 1200 Twelfth Ave., Altoona, Pa.

Lorenz, Frederick R., Jr., manager, special materials, Westinghouse Electric Corp., Bettis Atomic Power Laboratory, Box 1468, Pittsburgh 30, Pa.

McCallin, Robert J., technical service supervisor, Medusa Portland Cement Co., Wampum, Pa.

Peterson, Don W., chief chemist, Medusa Portland Cement Co., Wampum, Pa.

Reber, Karl William, metallurgist, MSA Research Corp., Callery, Pa. For mail: 31 Mt. Lebanon Blvd., Pittsburgh 28, Pa.

Sauereison, Phil F., vice-president, Sauereisen Cements Co., 1045 N. Canal St., Pittsburgh 15, Pa.

Rocky Mountain District

Stufflebean, John H., chief engineer, Blanton & Cole, 211 W. Pennington, Tucson, Ariz.

St. Louis District

Heckethorn Manufacturing and Supply Co., K. O. Kirker, chief engineer, Box 117, Dyersburg, Tenn.

Blasco, P. A., vice-president, manufacturing, The Vickers Petroleum Co., Inc., Potwin, Kans.

Bloss, Erwin E., partner, Horner & Shifrin, 1221 Locust St., St. Louis 3, Mo.

Coffman, Eugene F., engineer, Research and Development Dept., The Benson Manufacturing Co., Architectural Div., 1811 Agnes, Kansas City 27, Mo. For mail: 1905 Steele Rd., Kansas City 6, Kans.

Southeast District

Mueller & Faith Laboratories, John W. Mueller, Jr., general manager, 1553 E. Sunset Dr., South Miami 43, Fla.

Chase, George E., senior transmission engineer, Southern Electrical Co., Box 989, Chattanooga, Tenn.

Erwin, Robert, owner-operator, Erwin Chemical Laboratory, 3033 Grand Ave., Coconut Grove 33, Fla.

Miller, William G., chemist., Hunt Process, Corp.-Southern, Box 420, Ridgeland, Miss.

Reinsch, Robert T., mechanical engineer; section head, Research and Development Div., Florida Tile Industries, Inc., 608 Prospect St., Lakeland, Fla.

Walker, Howard R., technical superintendent, Abbeville Mills, Abbeville, S. C.

Southern California District

Downey, City of, Donald E. Donovan, chief inspector, Engineering Div., 8425 Second St., Downey, Calif.

Products Research Co., Irvin P. Seegman, technical director, 3126 Los Feliz Blvd., Los Angeles 39, Calif.

Anisman, Alfred M., chief chemist, W. J. Voit Rubber Corp., 1600 E. 25th St., Los Angeles 11, Calif.

Bouvier, George A., owner, George A. Bouvier and Associates, 119 S. Rosemead Blvd., Pasadena, Calif.

Burres, Warren G., district engineer, Portland Cement Assn., 816 W. Fifth St., Los Angeles 17, Calif.

Rendessy, Dorothy, executive secretary, Concrete Masonry Assn., 5205 Hollywood Blvd., Los Angeles 27, Calif.

Scott, Ronald F., assistant professor of civil engineering, California Institute of Technology, Pasadena, Calif.

(*Continued on page 100*)

Look to...

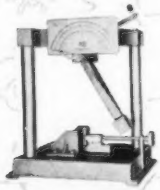
tmi

America's leading Manufacturer & Distributor of Physical Testing Machines

Several of the 1,079 testers available from TMI

PRECISION THICKNESS (Motorized Measurement)

COMPRESSION-TENSION FLEXURE-SHEAR



TENSION-IMPACT (The New Plastics Test)

MICRO HARDNESS (Rubber-Plastics-Coatings)

ROCKWELL HARDNESS

Write for data concerning all your testing equipment needs.

TESTING MACHINES INC.

72 Jericho Turnpike • Mineola, L. I., New York

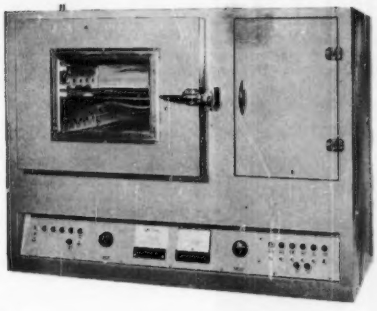
The finest Test Equipment for ALL Industries

FOR FURTHER INFORMATION CIRCLE 394 ON READER SERVICE CARD

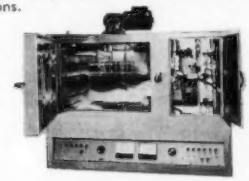
Reliable, Consistent Test Results With . . .

OREC 0300 *Automatically Controlled Ozone Test Chambers*

. . . certain factors associated with manual ozone measurement and control suggested the need for Automatically Controlled Ozone Test Chambers . . .



Orec 0300 Series employ an *electronic-chemical loop feed back servo system to achieve and precisely maintain chamber ozone concentrations.



Orec 0300 with Dynamic Stretching Apparatus.
*patent pending

OZONE:

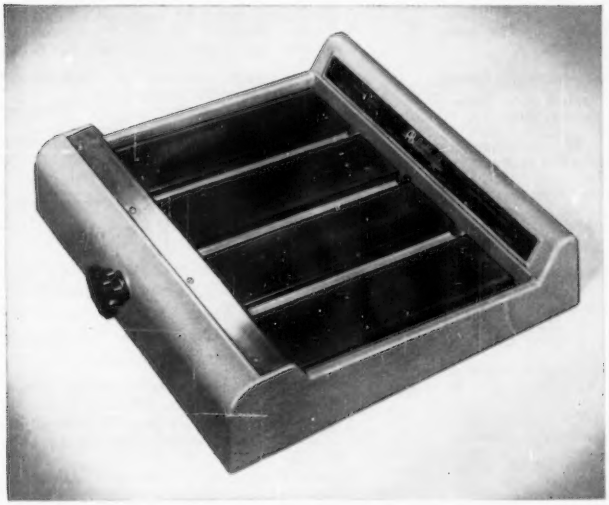
- TEST CHAMBERS, 6 MODELS
- AUTOMATIC CONTROL SYSTEMS
- RECORDING INSTRUMENTATION
- STRETCHING APPARATUS
- MEASUREMENT INSTRUMENTATION
- GENERATORS
- TESTING SERVICE
- RESEARCH & DEVELOPMENT

Write for illustrated brochure

Ozone Research and Equipment Corporation

3840 North 40th Avenue **Phoenix, Arizona**

FOR FURTHER INFORMATION CIRCLE 395 ON READER SERVICE CARD



No. 1470 AB HANDIMET GRINDER, complete $98.00

No. 1469-SW AB HANDIMET GRINDING PAPER for 1470 Grinder, Grits 240, 320, 400, 600 per 100....$10.00

No. 1469-1-SW AB HANDIMET GRINDING PAPER assorted 10 each grits 240, 320, 400, 600....$4.50

1470 AB

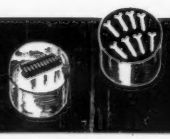
HANDIMET GRINDER

A New, Wet Hand Grinder for Metallurgical Samples

Now you may have wet grinding facilities for hand preparation in your laboratory at a nominal cost. Convenience at your fingertips, always clean and ready for use. Simply attach to water and drain facilities.

Individual elevated hard glass grinding surfaces are continually flushed with streams of water. This floats off the surface removal products, provides lubrication, and leaves sharp abrasive edges exposed at all times. A control valve permits complete selectivity of the volume of water. Ample drainage facilities with standard pipe fittings are provided at the rear. The grinding platforms are pitched downward and away from the operator.

The Handimet Grinding Paper is coated with a pressure sensitive adhesive backing and firmly holds when merely pressed against the flat grinding surface. It is easily removable when sheet is worn.

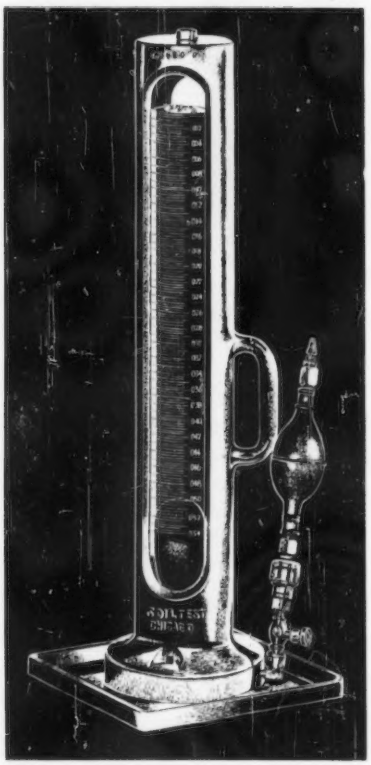


Buehler Ltd. METALLURGICAL APPARATUS

2120 Greenwood St., Evanston, Illinois, U. S. A.

FOR FURTHER INFORMATION CIRCLE 396 ON READER SERVICE CARD

SOIL COMPACTION



VOLUMEASURE
for fast, accurate
IN-PLACE
DENSITY
TESTING of SOILS

PRICE $95.00 F.O.B. CHICAGO

Write for complete Catalog of Engineering Test Apparatus.

SOILTEST Incorporated

4711 W. North Ave. • Chicago 39, Ill.
CIRCLE 397 ON READER SERVICE CARD

New Members

(*Continued from page 98*)

Stanley, Harold B., laboratory supervisor, Mesa Plastics Co., 12270 Nebraska Ave., Los Angeles 25, Calif. For mail: 279 Roundup Rd., Glendora, Calif.

Strauss, Fred A., principal engineer, Stetson, Strauss & Drassalhaus, Box 87, Porterville, Calif. For mail: 709 Second St., Porterville, Calif.

Southwest District

Gulf-Seal Corp., Jarl Sahol, vice-president, 1522 Melrose Bldg., Houston 2, Tex.

Green, Robert C., chief engineer, Southwest Fabricating and Welding Co., Box 9157, Central Park Station, Houston 11, Tex. For mail: 4419 Merwin St., Houston 27, Tex.

Hawthorne, Cooper F., vice-president and general manager, Meral Services, Inc., Box 217, Port Neches, Tex.

Washington (D. C.) District

Materials Testing Co., Inc., John H. Duddy, general manager, 4934 St. Elmo Ave., Bethesda 14, Md.

Canter, Clyde T., head, Technical Section, Cone Mills Corp., 1112 Maple St., Greensboro, N. C.

Drawbaugh, David G., Jr., engineer, maintenance methods and procedures, Western Maryland Railway Co., Hagerstown, Md.

Haverfield, John W., laboratory inspector, Cement Reference Laboratory, National Bureau of Standards, Washington 25, D. C. For mail: 11802 Judson Rd., Silver Spring, Md.

Kraas, Alfred H., partner, Gongwer, Kraas & Webb, 1115 17th St., N. W., Washington 6, D. C.

Maier, Leonhardt Freidrich, general engineer, J. George Stewart, Architect of the Capitol, United States Capitol, Washington, D. C. For mail: 721 McCabe Ave., Baltimore 12, Md.

Phillips, James F., structural test engineer, Brunswick-Balke-Collender Co., Box 102, Marion, Va. [A]

Siler, Theodore E., general engineer, U. S. Army, Corps of Engineers, Bldg. T-7, Washington 25, D. C. For mail: 791 Rollins Dr., Alexandria, Va.

Western New York-Ontario District

Pittsburgh Metallurgical Co., Inc., D. J. Porreca, chief chemist, Box 368, Niagara Falls, N. Y.

Bateman, Richard M., technical director, Rubber Div., Lovell Manufacturing Co., Box 1098, Erie, Pa.

Loubert, G. P., product manager, Industrial Insulations, Canadian Johns-Manville Co., Ltd., 565 Lakeshore Rd., Port Credit, Ont., Canada.

Outside Established Districts

Afong, Jacob, Jr., soils technician, K. B. Hirashima and Associates, 943 S. Queen St., Honolulu 14, Hawaii. For mail: 622 Punaa St., Kailua, Oahu, Hawaii. [A]

Lockard, E. Keith, partner, Lockard, Casazza & Parsons and Associates, 232 W. First St., Reno, Nev.

McCoy, B. L., Box 1623, Juneau, Alaska.

Newman, Gene J., electrical engineer, Plant Engineering Branch, Civil Aeronautics Administration, Box 45007, Airport Station, Los Angeles 45, Calif. For mail: 3306 S. 216th St., Seattle 88, Wash.

Walker, Daneil D., Jr., chief chemist, U. S. Lime Products Div., The Flintkote Co., Box 127, Henderson, Nev. For mail: 243 Basic Rd., Henderson, Nev.

Other Than U.S. Possessions

Le Ferrociment S. A., Pierre Pirotte, head, Research and Control Laboratory, Rue de l'Alliance, Marchienne-au-Pont, Belgium.

Arena, Salvador, president, Termomecanica Sao Paulo S. A., Rue Piratininga 875, Sao Paulo, Brazil. For mail: Caixa Postal 8169, Sao Paulo, Brazil.

Azeem, Mohammad, Atomic Energy Commission, Karachi, Pakistan. For mail: 11-A-6-26, Nazimabad, Karachi, Pakistan.

Bendesky, technical director, Dr. Jose Polak, S. A., Box 18981, Mexico 4, D. F., Mexico.

Bracka, Maurice V., ingenieur directeur général, Getraco Finmetal S. A., 30, avenue de l'Opera, Paris 2e, France.

Chiabotto, Luigi, Esso Standard Italiana, Via Assarotti 40, Genoa, Italy. For mail: Via Trento 8, Genoa, Italy.

Colman, M., assistant chief metallurgist, Canadian Steel Foundries, Ltd., Box 98, Montreal 4, P. Q., Canada.

Costa Rica Ministerio de Obras Publicas, Departmento Planeamiento, Apartado F., San Jose, Costa Rica.

Coyle, Michael B., Research Dept., Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester 17, England.

Garcia Ruffinatti, Jorge, civil engineer, Viollier 77, Santiago, Chile. [A]

Goco, Rodolfo J., Sr., soils technician, Morrison-Knudsen, Inc., Box 1601, Teheran, Iran.

Hertner, W., Box 15, Pratteln, Switzerland.

Kanellopoulos, George P., auto test engineer, Sistoy. No. 29 Nikaia, Pireaus, Greece. [A]

Kern, Walter F., manager, tire and rubber physical testing, Metzeler Gummiwerke AG, Westendstrasse 131–133, München 12, Germany.

Laboratorio del Transporte y Mecanica del Suelo, Jose Luis Escario, director, Alfonso XII, 3, Madrid, Spain.

Miranda, Joao Cancio, Jr., chief of chemistry, Refinaria de Petroleo Ipiranga S. A., Box 46, Rio Grande do Sul, Brazil.

Morton, Robert L., chief metallurgist, Consolidated Pneumatic Tool Co., Ltd., Tullos, Factory, Greenwell Rd., Aberdeen, Scotland.

Newton, L. R., technical librarian, de Havilland Propellers, Ltd., Hatfield, Hertfordshire, England.

Quebec Department of Roads, technical information engineer, Parliament Bldg., Quebec, P. Q., Canada.

Roldan, Pascual Gutierrez, general director, Petroleos Mexicanos, Ave. Juarez 94, Mexico 1, D. F., Mexico.

Samson, Moses A., materials engineer, U. S. Army District Gulf, Corps of Engineers, Box 1606, Teheran, Iran.

Santiago Direccion de Pavimentacion, Valentin Letelier No. 13, Santiago, Chile.

Schmidt, Patricio, partner, Piwonka & Schmidt, Ahumada 236-Of. 605, Santiago, Chile.

Technion-Israel Institute of Technology, Library, Box 4810, Haifa, Israel.

Velasco, Geronimo Z., general manager, Magsaysay Bldg., Manila, Philippines.

Zolkov, Elias, civil engineer, Department of Soil Engineering, Technion-Israel Institute of Technology, Haifa, Israel. [A]

OTS Research Reports

THESE REPORTS, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Dielectric Materials Moisture Resistance Study: Final Report, PB 151014, $2.

A New Basis for an Inspection Method for Sintered Metal Components, PB 151133, $2.25.

Tensile Properties of Titanium Alloys at Low Tempera ures, PB 151062, $1.25.

Brazed Honeycomb Core Titanium Panels, PB 151116, $2.

The Preparation and Properties of Experimental Binary Copper-Titanium Alloys, PB 151173, $1.

Thermophysical Properties of Solid Materials, PB 151715, $6.

Investigation of Fe-Mn-Cr-N-C System for Heat Resistance and Oxidation Resistance Between 1200 and 2000 F. Part 2, PB 151558, $2.50.

Investigation of the Properties of Tantalum and Its Alloys, PB 151562, $2.

(*Continued on page 117*)

NUCLEAR SYSTEMS
offers
CONTRACT RESEARCH
in

- **Non-destructive Testing**
- **Radiation Applications**
- **Thickness-Density Gaging**
- **Radiography**

Nuclear Systems is now developing a prototype scanning system for the high speed non-destructive inspection of very large solid propellant rocket engines. This program entails the application of thickness-density gaging to non-destructive testing, and is being sponsored by the Air Force through one of the largest producers of solid propellant fuels.

Similar systems should be applicable to less expensive inspection of heavy castings and weldments, and lead-filled radiation shields.

If you have a problem in any of the above areas, Nuclear Systems' engineers will be happy to discuss with you the establishment of an R & D program specifically designed to solve that problem in the most efficient, and therefore, most economical way.

PHILADELPHIA • CHICAGO • SAN FRANCISCO

NUCLEAR SYSTEMS

A DIVISION OF THE BUDD COMPANY, Philadelphia 32, Pa.

IN CANADA—TATNALL MEASURING AND NUCLEAR SYSTEMS, LTD.
46 HOLLINGER RD. • TORONTO 16, ONT.

Budd

FOR FURTHER INFORMATION CIRCLE 398 ON READER SERVICE CARD

NEWS OF MEMBERS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

Alfonso Abbate is associated with Société Routiere as a testing engineer in Ahwaz, Iran. Formerly he was materials testing engineer, Rome, Italy.

A. G. Ashcroft, formerly staff associate, Arthur D. Little Inc., New York, N. Y., and vice-president, research and engineering, Alexander Smith, Inc., is now research consultant, Bronxville, N. Y. Mr. Ashcroft is an active member of Committee D-13 on Textile Materials and a past-director of the Society.

Robert D. Atkins is now associated with Dunphy Associates, Inc., St. Paul, Minn., as a consulting engineer. Formerly he was standards and laboratory engineer, American Hoist and Derrick Co., St. Paul, Minn.

Alexander D. Barczak fills the new post of operational vice-president, Superior Foundry, Inc., Cleveland, Ohio. He had been plant manager.

Lynn S. Beedle, professor of civil engineering, Lehigh Univ., Bethlehem, Pa., and chairman of the Structural Metals Div., Fritz Engineering Laboratory, received the American Iron and Steel Institute's Regional Technical Meeting Award for the best paper in the field of research at the ASCE's 67th general meeting held in New York.

K. M. Berg, previously associated with Food Machinery and Chemical Corp., Market Development Dept., Westvaco Mineral Products Div., New York, N. Y., is now senior economist, Midwest Research Inst., Kansas City, Mo.

William E. Bond is now president, Industrial Laboratory Services, Pittsburgh, Pa. Formerly he was manager, Metallurgical Dept., Pittsburgh Testing Laboratory, Pittsburgh, Pa.

John M. Campbell, scientific director, Research Laboratories Div., General Motors Corp., and former national director of the Society, returned home late in September from the hospital, where he had been admitted with a mild heart attack. He is reported as having recovered very nicely, but as is very desirable in cases of this kind, he will make haste slowly. His home address is 1333 Glengarry, Birmingham 1, Mich.

Dodd S. Carr, previously director of research, Bart Laboratories and Design, Inc., Belleville, N. J., is now technical assistant, Chemical Industry, Freeport Nickel Co., New York, N. Y.

Harvey C. Christen, director, quality control, Lockheed Aircraft Corp., Burbank, Calif., has been made vice-chairman of the newly organized technical council of the Society for Nondestructive Testing.

Harold F. Clemmer retired July 1, 1959, as engineer of materials and standards, District of Columbia, Engineer Dept., Washington, D. C. Mr. Clemmer has been very active in Committee D-4 on Road and Paving Materials, having served as chairman from 1932 to 1934, and in the Washington, D. C., District Council, of which he was chairman for three years. He will continue his interest in the Society by retaining his individual membership, which dates back to 1915.

John E. Conrad, formerly superintendent, Rosemary Finishing Plant, J. P. Stevens and Co., Inc., Roanoke Rapids, N. C., is now technical superintendent, Sidney Blumenthal and Co., Burlington Industries, Inc., Rocky Mount, N. C.

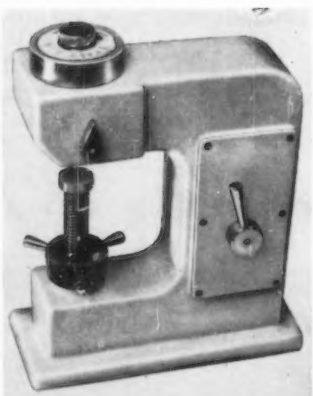
A. D. Conrow, a member of the Society since 1926, retired Oct. 31, 1959, as research engineer, Ash Grove Lime and Portland Cement Co., Chanute, Kans. Mr. Conrow represented his company in Society membership and also on Committees C-1 on Cement, C-7 on Lime, and C-9 on Concrete and Concrete Aggregates.

Robert S. Cunningham, in charge of

NEWAGE MICROHARDNESS TESTER

A PRECISION INSTRUMENT AT THE LOW PRICE OF

$575 complete



Eliminates need for microscope, conversion charts, complicated tables.

Permits direct, accurate readings corresponding to Vickers within seconds.

Perfect for rapid, accurate checking of surface layers, thin sheet, flat springs, instrument parts, wire punches. Can be obtained in 1 kg or 2 kg loads penetrating .000079" or .00016".

NEWAGE INDUSTRIES, INC.

222 York Road, Jenkintown 7, Pa.

CIRCLE 399 ON READER SERVICE CARD

another new high vacuum instrument from CENCO

THERMOCOUPLE GAGE

Continuously measures total pressure of gases in the range 1-1000 microns Hg. Direct reading, self-regulating, sturdily built for industrial use. 115 volt, 60 cycle AC operation. Write for details.

CENCO No. 94178, in compact metal case, each $110.00

cenco®

CENTRAL SCIENTIFIC CO.

A Subsidiary of Cenco Instruments Corporation

1718G Irving Park Road • Chicago 13, Illinois

Branches and Warehouses—Mountainside, N. J. Boston • Birmingham • Santa Clara • Los Angeles • Tulsa Houston • Toronto • Montreal • Vancouver • Ottawa

CIRCLE 400 ON READER SERVICE CARD

fabric, Lee Rubber and Tire Corp., Conshohocken, Pa., retired recently. He is now residing in Orlando, Fla. Mr. Cunningham joined the Society in 1947 and for five years was a member of Committee D-13 on Textile Materials.

Michael Czuha, Jr., has been promoted to senior research chemist, Central Research Div., Consolidated Electrodynamics Corp., Pasadena, Calif. He had been serving as research chemist, Research Div.

Henry K. Dice has been promoted to vice-president—technical director, Celanese Corporation of America, Clarkwood, Tex. Formerly he was director of research.

William A. Dupraw, until recently chief chemist, Columbia National Corp., Pensacola, Fla., is now with Crucible Steel Co., Pittsburgh, Pa.

Ernest E. Duque retired May 18, 1959, as president, California Portland Cement Co., Los Angeles, Calif. He will, however, remain on the board of directors.

Richard R. Egan is now technical director, Tidy House Products Co., Omaha, Nebr. Previously he was director, Applications Research, American Alcolac Corp., Baltimore, Md.

Raymond R. Fox, until recently senior designer, C. F. Braun and Co., Alahambra, Calif., is now associate professor of civil engineering, George Washington Univ., Washington, D. C.

Charles R. Funk, prior to becoming chief metallurgist, Eastern Div., Colorado Fuel and Iron Corp., was manager, metallurgy and engineering, Alco Products, Inc., Latrobe, Pa.

Maurice Greenberg, chief, testing and research, City of Detroit, Department of Public Works, City Engineers, has been appointed to the position of engineer of tests and research with the City Engineers Office, Detroit, Mich.

Edgar E. Hardy, formerly director of research, Mobay Chemical Co., New Martinsville, W. Va., is now associated with Monsanto Chemical Co., Springfield, Mass., as development associate.

Emil R. Hargett, who had been assistant professor, Dept. of Civil Engineering, Univ. of Florida, Gainesville, Fla., is now associate professor, Dept. of Civil Engineering, South Dakota State College, Brookings, S. Dak.

Walther L. Havekotte is associated with A. M. Byers Co., Ambridge, Pa., as chief project engineer. Previously he was metallurgist, Firth Sterling, Inc., Pittsburgh, Pa.

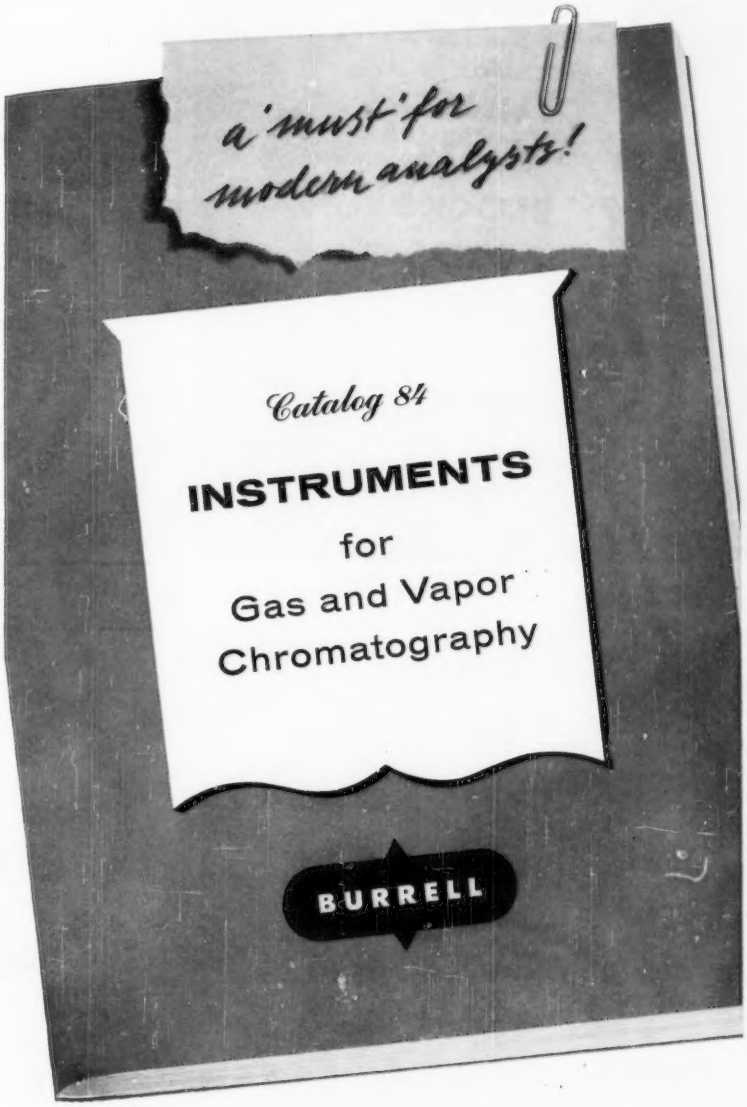
Albert G. Haynes, former owner and director of engineering and operation, Leo-

(*Continued on page 105*)

"For Scientists Everywhere"

Important new booklet

Now, for the first time in the dynamic history of modern chromatographic analysis, you can have a complete listing of instruments and accessories in one handy volume.



Only Burrell builds a complete series of laboratory instruments for chromatographic analysis, including four models of the versatile Burrell Kromo-Tog for research or process control.

Request Catalog 84

BURRELL *Scientific Instruments and Laboratory Supplies*

BURRELL CORPORATION, 2223 FIFTH AVENUE, PITTSBURGH 19, PA.

FOR FURTHER INFORMATION CIRCLE 401 ON READER SERVICE CARD

CONCRETE TESTERS

THE WORLD'S FINEST LOW COST PLANT AND JOB-SITE TESTERS
For
CYLINDERS
CUBES
BLOCKS
BEAMS
PIPE

IF IT'S A CONCRETE TESTER YOU NEED-GET IN TOUCH WITH

FORNEY'S, Inc.
TESTER DIVISION
P. O. BOX 310 · NEW CASTLE, PA.

CIRCLE 402 ON READER SERVICE CARD

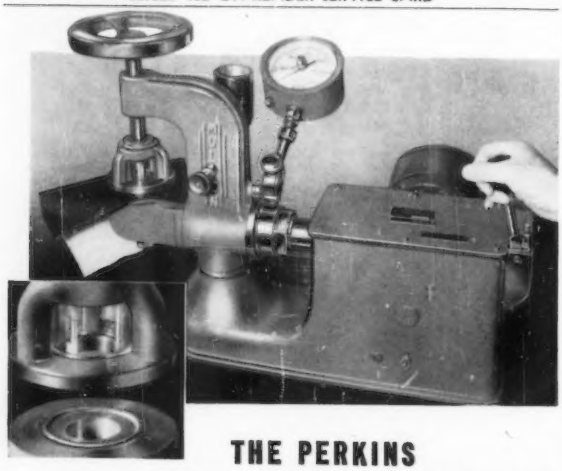
KLETT MADE

Colorimeters
Visual
Photo-Electric
Special Types For Testing
Colors Petroleum Products

Glass Color Standards
Glass Cells
Fluorimeter
Nephelometer

KLETT MANUFACTURING COMPANY
Manufacturers of Scientific Instruments
179 E. 87th Street New York 28, N. Y.

CIRCLE 403 ON READER SERVICE CARD



THE PERKINS HYDROSTATIC PRESSURE TESTER

For water penetration tests on water proofed fabrics. Tests either flat cloth or seams.
Also tests bursting strength of plastic films.
Available with hand or motor drive.

Write today for full information —

B. F. PERKINS & SON, INC.
TESTER DIVISION BOX 388
HOLYOKE, MASSACHUSETTS

CIRCLE 404 ON READER SERVICE CARD

NEW!
CENCO®
FORCED CIRCULATION
RECTANGULAR OVENS

All stainless steel interiors. Temperature range 60-250°C. Fitted to take glass inner door. Model 95375, 12″x12″x14″ inside . . . $315.00. Model 95380, 17″x15″x20″ inside . . . $395.00.
Write for Bulletin 5B.

cenco®

CENCO the most complete line of scientific instruments and laboratory supplies in the world.
CENTRAL SCIENTIFIC CO.
1718G Irving Park Road • Chicago 13, Illinois
Branches and Warehouses — Mountainside, N. J. Boston • Birmingham • Santa Clara • Los Angeles • Tulsa Houston • Toronto • Montreal • Vancouver • Ottawa

CIRCLE 405 ON READER SERVICE CARD

News of Members

(*Continued from page 103*)

Aires Industries, Maywood, Ill., is now director, Keeney Research Div., Inc., subsidiary of J. H. Keeney and Co., Inc., Chicago, Ill.

Robert B. Hobbs, chief of paper section at National Bureau of Standards, received the U. S. Dept. of Commerce Silver Medal for Meritorious Service. He was cited for "valuable contributions to the science and technology of leather and paper" and for "highly distinguished authorship."

J. Stuart Hunter, prior to becoming statistician, Mathematics Research Center, Univ. of Wisconsin, Madison, Wis., was research associate, Princeton Univ., Princeton, N. J.

Matthew A. Hunter, dean emeritus of Rensselaer Polytechnic Inst., received the 1959 Gold Medal of the American Society for Metals. Dr. Hunter is being honored by the Society in recognition of the devotion of a lifetime to advancing metallurgical education.

C. E. Jackson is associated with Central Cable Corp., Jersey Shores, Pa., as technical director. Previously he was chief chemist, Paranite Wire and Cable Corp., Jonesboro, Ind.

Harry E. Jordan, secretary, American Water Works Assn., New York, N. Y., retired Sept. 1, 1959. Mr. Jordan was the association's first full-time secretary in 1936 and for a number of years represented AWWA in ASTM membership.

R. H. Keedy is now manager, hermatic refrigeration repair, Acre Service, Dallas, Tex. Formerly he was partner, Acme Electric, Fort Worth, Tex.

A. P. Kivlin, chief of laboratories, Freight Loading and Container Bureau, Association of American Railroads, Chicago, Ill., retired Sept. 1, 1959, after 36 years of service. Mr. Kivlin represented AAR on Committees D-6 on Paper and Paper Products and D-10 on Shipping Containers.

John H. Knowles, director, engineering coordination, Dorr-Oliver, Inc., Stamford, Conn., retired Sept. 30, 1959. Mr. Knowles joined the Society in 1956.

Peter Leckie-Ewing has joined the metallurgical staff of Latrobe Steel Co., Latrobe, Pa. He was previously with Landis Machine Co., Waynesboro, Pa.

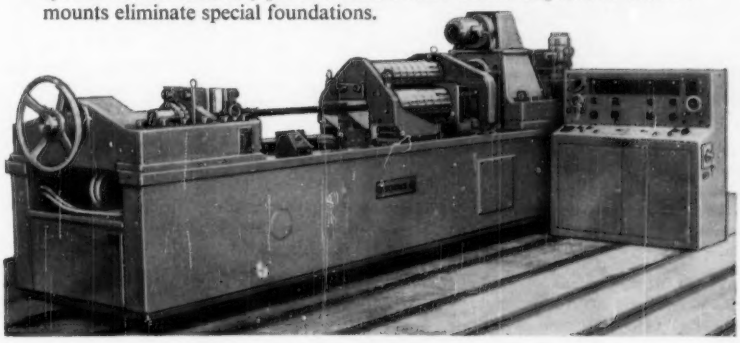
Martin L. Lewis, former manager, Tape Dept., H. K. Porter Co., Inc., Philadelphia, Pa., is now product manager, Permacel, New Brunswick, N. J.

Homer H. Lowry, Wilmerding, Pa., was presented with the Percy Nicholls Award for 1959. This is a joint honor of the American Institute of Mining, Metallurgical, and Petroleum Engineers and The American Society of Mechanical Engineers. Dr. Lowry received the award

(*Continued on page 106*)

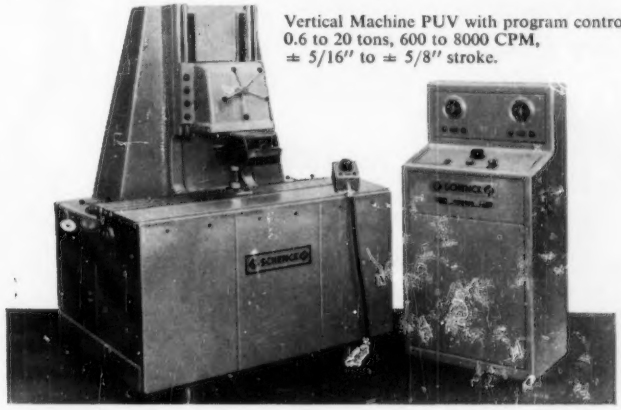
Multi-Purpose SCHENCK
Fatigue Testing Machines
HIGH SPEED—COMPLETELY ADJUSTABLE FOR RESEARCH AND PRODUCTION TESTING

Exclusive Schenck fatigue testers offer more outstanding features. Test tensile strength, torsion, bending fatigue of any material, soft (rubber-plastics) or hard (steels). Basic push-pull action. High speed cycling permits rapid plotting of S-N curves. Built-in controls provide infinitely variable adjustment for frequency range, static and dynamic loads. Patented optical system measures loads, provides continuous visual inspection. Rubber mounts eliminate special foundations.



Horizontal Machine PB with program control.
3 to 100 tons, 280 to 4500 CPM, ± 1″ to ± 2″ stroke.

The Schenck PB horizontal (above) with long stroke and additional low speed drive applies rapid stress reversals with high loads—provides closest possible simulation of operating conditions. The Schenck PUV vertical (below) features many exclusives capacities of PB, but saves space through vertical design which makes it the ideal laboratory testing machine.



Vertical Machine PUV with program control.
0.6 to 20 tons, 600 to 8000 CPM,
± 5/16″ to ± 5/8″ stroke.

Schenck horizontal type PP (not illustrated).
2 to 60 tons, 2000 to 2600 CPM, ± 3/16″ to ± 9/32″ stroke.

Various gripping devices, load multipliers, heating-freezing chambers and program controls available for most, if not all, models.

Write Today For Further Information!

COSA — *nationwide sales and service of precision machine tools—from bench lathes to boring mills.*

COSA CORPORATION, 405 LEXINGTON AVENUE, NEW YORK 17, N.Y.

FOR FURTHER INFORMATION CIRCLE 406 ON READER SERVICE CARD

News of Members

(*Continued from page 105*)

"in recognition of outstanding achievement in the field of solid fuels."

John R. MacGregor, research coordinator, petroleum products, California Research Corp., San Francisco, Calif., has been elected a vice-president and director, in charge of petroleum products research.

L. J. Markwardt, a member of the Society since 1920 and past-president, retired Sept. 30, 1959, as assistant director, U. S. Forest Products Laboratory, Madison, Wis. Mr. Markwardt will retain his Society membership and continue to participate in technical committee activities.

Frank A. Marston, partner, Metcalf & Eddy, Boston, Mass., has assumed the presidency of the American Society of Civil Engineers. Mr. Marston has been a member of ASTM for almost 20 years.

J. Miguel Marquez B. is in charge of civil engineering, Instituto Venezolano del Hierro y del Acero, Bolivar, Venezuela. He had been with a Special Commission of Studies, Government of Venezuela, at Bethlehem Steel Co., Bethlehem, Pa.

Philip Maslow, former supervisor, coatings laboratories, Ciba Co., Inc., Kimberton, Pa., is now technical director, Permagile Corp. of America, Woodside, N. Y.

Thomas L. Mayer, head, Dept. of Technology, Buffalo and Erie County Public Library, Buffalo, N. Y., retired recently. Mr. Mayer was the first secretary of the Western New York–Ontario District Council from 1943 to 1946, and served as chairman of that district from 1946 to 1948.

T. W. Morrison has been appointed director, engineering and research, SKF Industries, Inc., Philadelphia, Pa. He had been manager, research laboratory.

W. G. Mullen is instructor, Civil Engineering Dept., Univ. of Maryland, College Park, Md. Formerly he was resident engineer, Madigan-Hyland, Long Island City, N. Y.

George G. Oberfell, consultant, Phillips Petroleum Co., Bartlesville, Okla., received the Walton Clark Medal from The Franklin Inst., Philadelphia, Pa. The medal was presented to Dr. Oberfell on Oct. 21, 1959, Medal Day, and the citation was "in consideration of his significant contributions to the development of liquid petroleum gas as a source of domestic fuel." Dr. Oberfell is an honorary member of ASTM technical Committee D-2 on Petroleum Products and Lubricants.

J. Arthur Paget, formerly affiliated with Combustion Engineering Superheater, Ltd., Montreal, Can., as senior design engineer, is now manager, research staff, General Atomic, San Diego, Calif.

H. A. Pasman, concrete inspector, Erie Railroad Co., Jersey City, N. J., retired recently. Mr. Pasman represented his company's membership in the Society and also on Committees C-1 on Cement, C-9 on Concrete and Concrete Aggregates, and D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses.

N. S. Perkins, technical director, Douglas Fir Plywood Assn., Tacoma, Wash., has been made special assistant to the managing director.

Richard C. Phoenix, previously ceramic engineer, Moore & Munger, New York, N. Y., is associated with Southern Clays Inc., New York, N. Y., as ceramic engineer.

Stanley L. Proud, prior to becoming engineer of foundations, Pacific Architects and Engineers, Headquarters, KMAG, APO, San Francisco, Calif., was senior materials engineer, Raymond Concrete Pile Co., Pereira, Colombia.

G. A. Robinson has been elected president of the National Clay Pipe Manufacturers, Inc., Washington, D. C. Mr. Robinson had served for the past six years as the association's vice-president in charge of Washington activities and government relations.

(*Continued on page 108*)

Cady Testing Instruments are Known

for Accuracy and Dependability

FOR BURST TEST
FOR THICKNESS
FOR BASIS WEIGHT

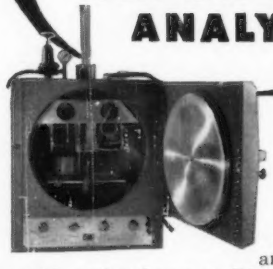
Complete line of desk, lab and portable micrometers, Burst Testers, Scales . . .

E. J. CADY & COMPANY
686 N. Harlem Ave.
River Forest, Ill.

Write for Brochure and Prices.

CIRCLE 407 ON READER SERVICE CARD

LOW COST
Gas Chromatography
CENCO®
VAPOR PHASE ANALYZER



Newest instrument completely versatile, proved for industrial control and research. Obtains chemical separations in minutes. Provides reproducible qualitative and quantitative analyses quickly and at low cost. Write for Bulletin 275.

No. 70130: complete with gas sampling valve but without recorder $995.00

cenco®

CENCO the most complete line of scientific instruments and laboratory supplies in the world.

CENTRAL SCIENTIFIC CO.
1718G Irving Park Road • Chicago 13, Illinois
Branches and Warehouses — Mountainside, N. J. Boston • Birmingham • Santa Clara • Los Angeles • Tulsa Houston • Toronto • Montreal • Vancouver • Ottawa

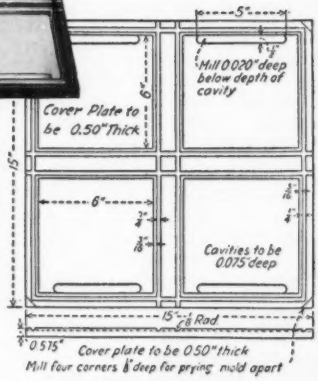
CIRCLE 408 ON READER SERVICE CARD

HOGGSON

TOOLS, MOLDS, DIES

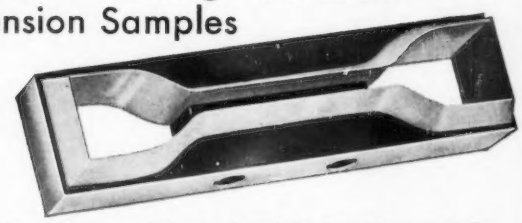
For Rubber Testing to ASTM Standards

Precision-Cut
SLAB
MOLDS



For making tensile test samples, we supply single and multicavity slab molds as shown, in plain or chrome finish, with or without handle and hinges. We usually stock molds for adhesion, abrasion, flexing, compression and rebound samples. Special molds promptly.

Dies for Cutting "Dumbbell" Tension Samples



These dies are milled out of steel blocks; edges carefully ground and specially hardened to cut vulcanized rubber. Entire die precision designed to ASTM standards. For machine use as shown, or with handle for hand operation. Also, hand-forged dies to cut regular or tear test samples.

BENCH MARKER

1" and 2" Centers

MALLET HANDLE DUMBBELL DIE

HOGGSON & PETTIS MANUFACTURING CO.
133 Brewery St. • NEW HAVEN 7, CONN.
Pacific Coast, H. M. Royal, Inc., Downey, Calif.

CIRCLE 409 ON READER SERVICE CARD

TEMCO®

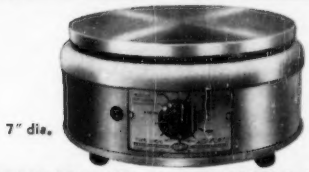
HOT PLATES

the wide line that lets you
select the exact type and size you need
for your own specific applications

All models stainless steel cases, scientifically ventilated.

"AMERICA'S GREATEST HOT PLATE VALUE

TYPE 1900 Ideal for wide variety of critical and routine lab uses. Wide temperature range with exceptionally close control. Cast aluminum top plate, stainless steel case. 115V AC $22.75 (Also available for 230 V.)

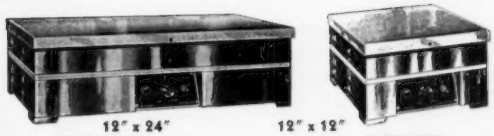


FINE PERFORMANCE . . . HANDSOME APPEARANCE

TYPE 2500 Extra-sensitive thermostat provides stepless control from room temperature to 370° C. Cast aluminum top plate stainless steel body. $32.50.

FOR HEAVY-DUTY WORK . . . TYPE 2600

Designed especially to stand hard use for prolonged periods. Cast iron top plate, stainless steel body. Excellent for heavy-demand process control or plant production lines. 4-heat control 115V or 230V AC $45.00.



TYPE 2100 **TYPE 2000**

GENERAL-PURPOSE LAB OR PLANT UNITS

Cast aluminum top plate heats fast, evenly. 60°C. to 450°C range. Built-in a.c. control provides completely variable temperature regulation. Stainless steel body. $80 and $115

Write today for free literature and name of nearest dealer.

THERMO ELECTRIC MFG. CO.
472 Huff Street, Dubuque, Iowa

CIRCLE 410 ON READER SERVICE CARD

News of Members

(*Continued from page 106*)

S. J. Rosch retired Nov. 30, 1959, as consulting cable engineer, Anaconda Wire and Cable Co., Hastings-on-Hudson, N. Y. For many years, Mr. Rosch served on Committees D-9 on Electrical Insulating Materials, D-11 on Rubber and Rubber-Like Materials, D-13 on Textile Materials, and D-27 on Electrical Insulating Liquids and Gases. Recognizing Mr. Rosch's work on Committee D-11, this committee elected him to Honorary Membership in 1958.

P. N. Russell is now senior scientist, Hoffman Science Center, Santa Barbara, Calif. Formerly he was manager, dielectric and magnetic materials, Electronics Laboratory, General Electric Co., Syracuse, N. Y.

Joseph Schwaighofer, previously assistant professor, The Pennsylvania State Univ., University Park, Pa., is now assistant professor, Dept. of Civil Engineering, Univ. of Toronto, Toronto, Canada.

Morton W. Scott is staff assistant, Revlon, Inc., New York, N. Y. He had been pharmaceutical engineer, Johnson & Johnson, New Brunswick, N. J.

Fred B. Seeley, formerly professor and head, Dept. of Theoretical and Applied Mechanics, Univ. of Illinois, Urbana, Ill., is now engineering professor, emeritus, Univ. of Illinois.

Frank T. Sisco, previously director, Engineering Foundation, New York, N. Y., is now director, Alloys of Iron Research, New York, N. Y.

G. Frederick Smith, professor of chemistry, Univ. of Illinois, Urbana, Ill., received the 7th Annual Anachem Award of the Association of Analytical Chemists. The award is given for outstanding contributions to analytical chemistry and was presented at the Anachem Conference in Detroit.

Richard M. Spriggs, formerly senior research engineer, Ferro Corp., Cleveland, Ohio, is associated with AVCO Corp., Wilmington, Mass., as senior scientist. Research and Advanced Development Div.

W. Lee Stewart is currently product manager, Hanlon & Goodman Co., Suffern, N. Y. He had been assistant mechanical engineer, American Brake Shoe Co., Mahwah, N. J.

Ernest A. Sticha was named chief research metallurgist by Edward Valves Inc., East Chicago, Ind., subsidiary of Rockwell Mfg. Co. He was supervising engineer for Crane Co., Chicago, Ill.

John F. Thompson, a 50-year member of ASTM and chairman of the board of The International Nickel Co. of Canada, Ltd., presented the key to the first permanent school in Thompson, Manitoba, to Mr. Carl Nesbitt, chairman of the school board, on Sept. 10, 1959. The school is the first of three elementary schools and one high school to be built by Inco at Thompson, which is near the company's new nickel mining project. The town and adjacent mine and plant were named in honor of Dr. Thompson who, in 1956, completed 50 years of service with International Nickel.

A. G. Timms is now associated with the U. S. Bureau of Reclamation, Washington, D. C., as highway research engineer.

Paul M. Unterweiser, metallurgical editor, *The Iron Age*, Philadelphia, Pa., was recently named an associate editor of *Metals Handbook*.

Theodore W. VanZelst, president, Soiltest, Inc., Chicago, Ill., has been elected a vice-president of Cenco Instruments Corp. and a director of Central Scientific Co., a Cenco subsidiary.

Vincent C. Vesce, technical director, B. F. Goodrich Chemical Co., Harmon Colors, Hawthorne, N. J., presented the annual Joseph J. Mattiello Memorial Lecture at the 37th Annual Meeting of the Federation of Paint and Varnish Production Clubs, which was held in Atlantic City, in October. The subject of his lecture was "Exposure Studies of Organic Pigments in Paint Systems."

A. J. Warner has resigned his position as consultant with DeBell and Richardson, Inc., Hazardville, Conn., and is now associated with Aerovox Corp., New Bedford, Mass., as manager, research and engineering.

R. G. Westerman, formerly chemical engineer, Ford Motor Co., Dearborn, Mich., is with the Ordnance Tank Automotive Command, Detroit Arsenal, Center Line, Mich., as chemical engineer.

Ralph D. Wysong, manager, manufacturing research, The Studebaker-Packard Corp., South Bend, Ind., was recently elected national president of the American Electroplaters' Society at the organization's Golden Jubilee Convention.

DEATHS

R. G. Coleman, chief, Materials Laboratory, Massey-Ferguson, Inc., Detroit, Mich. (recently). Mr. Coleman represented his company in Society membership.

M. Dann, executive assistant, Wyeth Laboratories, Inc., Philadelphia, Pa. (July 3, 1959). Mr. Dann was Wyeth's representative in ASTM membership.

Wheeler P. Davey, professor emeritus, Dept. of Physics, The Pennsylvania State University, University Park, Pa. (Oct. 12, 1959). A member of the Society since 1949, Prof. Davey participated in the work of Committees E-4 on Metallography, E-7 on Nondestructive Testing, and the Joint Committee on Chemical Analysis by Powder Diffraction Methods,

(*Continued on page 110*)

Atlas-Ometers

...Used all over the world

Give quick accurate answers to the deteriorating effect of sunlight, weathering, washing and wearing of materials. A few minutes, hours, or days in Atlas-Ometers equals years of normal use deterioration.

Indispensable for speed testing in product development and quality control in production. Exact standardized test programs can be repeated as frequently as required.

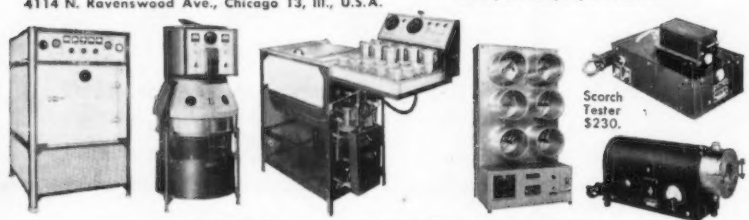
Used extensively in these industries:

Clothing makers	Automotive industry
Printing ink manufacturing	Consulting laboratories
Plastic and coated fabrics	Woolens and worsteds
Electric manufacturing	Rugs and carpets
Dyestuffs and chemicals	Soaps and detergents
U.S. Government	Paint, varnish, dry colors
Rubber products	and many others

Complete manual on each machine on request

Atlas Electric Devices Company
4114 N. Ravenswood Ave., Chicago 13, Ill., U.S.A.

Weather testing translucent fiberglas for outdoor use in an Atlas Weather-Ometer at the Alsynite Company of America.

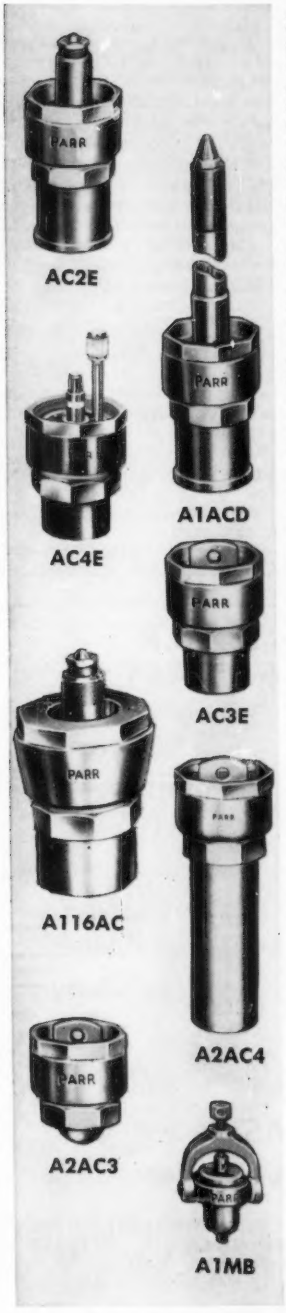


Weather-Ometer® $2755 up. | Fade-Ometer® $1350 up. Complete with supplies. | Launder-Ometer® $875 complete with accessories and supplies. | Random Tumble Pilling Tester $485 to $890. | Accelerator® $485.

FOR FURTHER INFORMATION CIRCLE 411 ON READER SERVICE CARD

PARR BOMBS

For rapid combustion and fusion reactions with sodium peroxide, and for other laboratory purposes



AC2E **22 ml.**
This is a general-purpose bomb with electrodes for hot wire ignition. It is widely used for determining sulfur, chlorine, phosphorus and other elements in a great variety of combustible organic materials. Furnished with a 94% Ni cup and Ni-plated brass cover. Other cups and covers are available.

A1ACD **22 ml.**
This bomb is the same as AC2E except it has a 5-inch stem for use in the Parr peroxide bomb calorimeter. It is used for measuring heats of combustion, also for chemical analyses following calorimetric tests.

AC4E **22 ml.**
This bomb is similar to AC2E except it has a gas connection for purging with an inert gas. It is used with a Parr 1411 calorimeter for measuring the heats of combustion of thermite and other self-burning pyrotechnic mixtures.

AC3E **22 ml.**
This bomb has a plain cover without electrodes. It is used for sodium peroxide reactions which can be started by heating with a gas torch. Cups of 94% Ni, 36% Ni, 99+% Ni, carbon steel and stainless steel are available.

A116AC **42 ml.**
This bomb is similar to AC-2E except all parts are larger and heavier than in the 22 ml. bomb. It will accommodate samples twice as large as AC2E and AC3E.

A2AC4 **45 ml.**
This bomb is the same as AC3E except the cup is 3⅞" deep to provide a 45 ml. internal volume. Cups of stainless steel, 94% nickel and 99+% nickel are available.

A2AC3 **8 ml.**
This bomb is similar to AC3E except it has a smaller cup with a hemispherical bottom. Sodium peroxide reactions are started by heating with a gas torch. The cup is 94% nickel.

A1MB **2.5 ml.**
This is the smallest of the several Parr peroxide bombs. It has a 94% nickel cup and cover, and is used for treating micro samples.

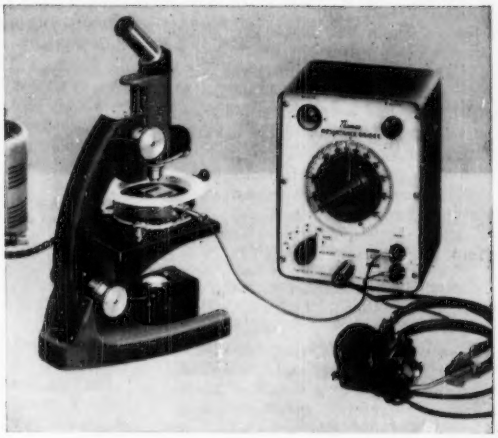
Ask your PARR Dealer for details, or write direct

PARR INSTRUMENT CO.
MOLINE, ILLINOIS

CIRCLE 412 ON READER SERVICE CARD

Thomas

AUDIOHM THERMISTOR *for* KOFLER HOT STAGE



. . . for determining melting points by use of a thermistor in place of mercury-in-glass thermometers

AUDIOHM THERMISTOR ACCESSORIES, for use with any Thomas-Kofler Hot Stage. Replace stage-calibrated thermometers and provide an audible signal which *eliminates the necessity for removing the eye from the microscope.* They offer faster response because the smaller sensor can be located closer to the field of observation than is possible with a thermometer. This sensor covers the entire temperature range up to 350°C.

Uninterrupted observation of fusion through all phases is made possible by measuring temperature as a function of thermistor resistance, which can be determined at any given instant by manually nulling the audible bridge signal. A simple graphic reader converts resistance values directly to temperature readings.

The Bridge Alarm (not shown above) signals approach to a preset balance point, permitting the operator to leave the stage unattended while it heats or cools.

6887-C2. Audiohm Thermistor Hot Stage Assembly, Thomas-Kofler, complete as illustrated, consisting of Hot Stage with transformer, Thermistor Attachment for the stage, Audiohm Resistance Bridge, Earphones, and Thermistor Temperature Computer; without miscroscope or bridge alarm. For 115 volts, 50 or 60 cyc. a.c. **422.95**

6887-B. Thermistor Hot Stage Attachment, for use on any Thomas-Kofler Hot Stage **50.25**
3963-A5. Resistance Bridge, Thomas Audiohm **228.00**
3963-A7. Bridge Alarm, Buzzer Type, Thomas (not shown above) **58.50**
3950-M2. Earphones **12.00**
6884-F. Thermistor Temperature Computer, Thomas **20.00**

More detailed information sent upon request.

ARTHUR H. THOMAS CO.

Laboratory Apparatus and Reagents

VINE STREET AT THIRD

PHILADELPHIA 5, PA.

More and More Laboratories RELY ON THOMAS

CIRCLE 413 ON READER SERVICE CARD

Deaths

(*Continued from page 108*)

of which he was honorary chairman. In appreciation of his work, Committee E-7 elected him to Honorary Membership in 1952.

Ernest W. Dean, 140 Stanmore Place, Westfield, N. J. (Oct. 16, 1959). Until the time of his retirement in 1953, Dr. Dean was consulting chemist, Standard Oil Development Co., New York, N. Y. Since 1924, he had been actively engaged in the work of Committee D-2 on Petroleum Products and Lubricants. In recognition of his long and faithful service to that committee, he was elected to Honorary Membership in 1953. Dr. Dean also represented the American Petroleum Inst. on ASA Project Z11.

Frederick H. Frankland, Frankland and Lienhard, New York, N. Y. (Nov. 1, 1959). For 26 years Mr. Frankland was active in committee work, having been a member of Committees A-1 on Steel, A-5 on Corrosion of Iron and Steel, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, and D-1 on Paint, Varnish, Lacquer, and Related Products.

R. H. Harriss, managing director, R. H. Harriss, Proprietary, Ltd., Johannesburg, South Africa (July 22, 1959). Mr. Harriss had been a member of the Society for 33 years.

R. H. Hobrock, vice-president and director of research, Research Laboratories, Bundy Tubing Co., Birmingham, Mich. (Sept. 10, 1959). Mr. Hobrock joined ASTM in 1936.

Wilmer H. Koch, works chemist, Niagara Operations, Olin Mathieson Chemical Corp., Niagara Falls, N. Y. (Sept. 24, 1959). During his 27 years of membership in the Society, Mr. Koch served on Committees D-12 on Soaps and Other Detergents (vice-chairman from 1956 to 1959), and E-2 on Emission Spectroscopy, as well as the Western New York–Ontario District Council.

B. P. Mulcahy, president, Fuel Research Laboratory, Inc., Indianapolis, Ind. (Aug. 31, 1959). Mr. Mulcahy's membership in the Society and participation in committee work goes back to 1938. He served Committee D-5 on Coal and Coke, Committee D-3 on Gaseous Fuels, and was a member of the Ohio Valley District Council for two years.

Bert Myers, materials engineer, Iowa State Highway Commission, Ames, Iowa (Sept. 14, 1959). Mr. Myers represented the Commission on Committee C-9 on Concrete and Concrete Aggregates for 18 years.

Julian Nardi, chief mechanical engineer, Ford, Bacon & Davis, Inc., New York, N. Y. (Oct. 30, 1959). Mr. Nardi was among the 26 persons who died in a Piedmont Airlines plane crash in Virginia.

Edward Randa, manager of technical service, Soap Div., Armour & Co., Chicago, Ill. (recently). Mr. Randa represented Armour on Committee D-12 on Soaps and Other Detergents. He also was a member of the Joint AOCA–ASTM Committee on Analysis of Soaps and Synthetic Detergents.

Henry J. Schweim, western manager, Gypsum Assn., Hollywood, Calif. (Oct. 11, 1959). For many years, Mr. Schweim represented the Gypsum Assn. in Society membership. He actively participated in the work of Committees C-11 on Gypsum, of which he was secretary for 21 years, C-12 on Mortars, E-5 on Fire Tests of Materials and Construction, and E-8 on Nomenclature and Definitions. In recognition of his service to the Society, Mr. Schweim was presented with an Award of Merit in June, 1959.

H. C. Stone, general superintendent, Belle City Malleable Iron Co., Racine, Wis. (Sept. 1, 1959). Mr. Stone represented his firm in Society membership as well as on Committee A-7 on Malleable-Iron Castings.

Robert C. Wheeler, Barker & Wheeler, Albany, N. Y. (Aug. 26, 1959). Mr. Wheeler had been a member of the Society for 20 years.

TENSILKUT®

Pat. Pend., U.S., Canada

● Now with TENSILKUT, whatever your testing methods or materials, you can have perfect precision machined physical test specimens in less than two minutes.

● TENSILKUT precision machines all foil, film, sheet and plate metals . . . from .0005″ foil to .500″ plate. Hard .001 stainless steel foil to soft ½″ aluminum, soft plastic film 1 mil in thickness or the abrasive glass laminates in .500″ plate, are machined with specimen configurations accurate to ± .0005″. Machined edges are completely free of cold working or heat distortion and require no hand finishing.

● TENSILKUT table and floor models are available with motors from ½ to 2½ h.p. Write for free brochure.

SIEBURG INDUSTRIES INCORPORATED
Danbury Industrial Park, Danbury, Connecticut

CIRCLE 414 ON READER SERVICE CARD

NAEF SAMPLE CUTTING PRESS

for Improved Accuracy, Lower Cost in Preparing Test Specimens for the Textile, Paper, Leather, Rubber and Plastic Industry

Presses available from stock.

Dies to ASTM or customer's specifications.

Meets D624-54, D412-51T, D39-49, D1175-55T, D1375-55T, D1117-53, D1230-52T, D1295-53T, D378-51T, D380-51T, D1004-39T Requirements

SMS INSTRUMENT COMPANY
P. O. Box 24, Rensselaer, N. Y.

CIRCLE 415 ON READER SERVICE CARD

NEWS NOTES ON
Laboratory Supplies and Testing Equipment

Note. This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

Laboratory Items

Vacuum Balance—A new automatic recording vacuum balance is now available. This new balance has the advantages of being able to weigh samples in air or inert gases at atmospheric or reduced pressures, at room or higher temperatures, on the balance pan or suspended below the balance in a furnace for thermogravimetry or differential thermal weighing.
Wm. Ainsworth & Sons, Inc. 3239

Sampling Device—The Auto-Sampler transfers samples automatically to and from the measurement cell of a spectrophotometer, polarimeter, refractometer, or other analytical instrument, or collects samples from a source such as a sample line, chromatographic column, fractionating column, etc. Operated in conjunction with an analytical instrument, it provides a fully automatic system for sample handling and analysis.
Applied Physics Corp. 3240

Resistance Bridge—The Model 8516 Pilotal ohmmeter provides precision automatic production testing of components and assemblies within preset resistance ranges.
Associated Research, Inc. 3241

Strain Indicator—A new direct-reading strain indicator with extremely wide range and sensitivity, the Model DR-20, is designed for use with all commercial strain gages and strain-gage transducers.
Bytrex Corp. 3242

Electronic Thermometer—New Thermophil 115-v or battery-powered electronic thermometers, which are standardized to permit interchangeability and are stabilized against drift, are now available. Reproducible readings registering from 200 to 450 C can be obtained.
Chicago Apparatus Co. 3243

Color Monitor—The new Sens-OAR-chrome is a compact, lightweight, electronic color monitor and control unit, capable of displaying information revealing variations in hue (principal observed wavelength) and in intensity (at that wavelength) of light received from test samples.
Comapco, Inc. 3244

Test Chamber—Redesigned FRL environmental test chamber is available. This unit is manufactured to be inserted in a tensile test machine from either the front or the back.
Custom Scientific Instruments, Inc. 3245

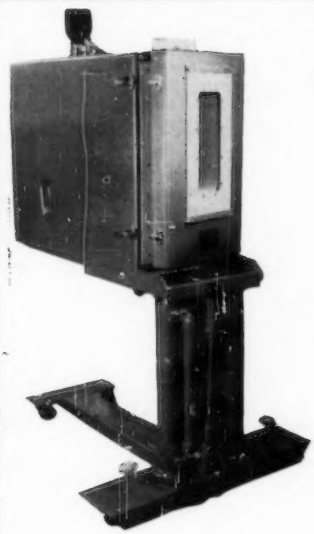
Magnetic Clutch—New magnetic clutch and brake line features high torque ratings with extreme reliability and long life under full torque loads. The newly developed line encompasses 9 models in 5 frame sizes—6 in.-oz (size 5) to 224 in.-oz (size 18)—with power consumption ranging from 2.5 w (size 5) to 5 w (size 18).
Dynamic Instrument Corp. 3246

Galvanometer—A new Scalamp galvanometer, compact and portable with a projection system and 15-cm scale, is available.
The Ealing Corp. 3247

Color Motion Picture Film—A new, high-speed, color motion picture film, Kodak Color Reversal Film SO-260, for use in recording scientific and technical data under unfavorable lighting conditions, has been introduced. This film, with a normal exposure rating of 160, has been successfully exposed at indexes up to 500.
Eastman Kodak Co. 3248

Circular Slide-Rule—A new, pocket-size, circular slide rule is now being offered for industrial and business use.
Edmund Scientific Co. 3249

(Continued on page 112)

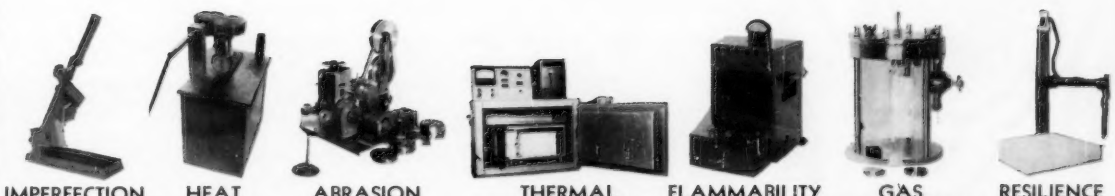


New **FRL ENVIRONMENTAL TEST CHAMBER**

This chamber was designed to give more versatility at a lower price. The standard model is manufactured for a temperature range of −90° to +700° F. The carriage is hydraulic operated and it may be rolled in either from the front or back of the tensile tester. The adjustable height is 28″ to 43″. The chamber is a two compartment electric oven or ice chest with the chamber divided vertically.

Shown below are physical testers in the plastics field. For further information write for individual brochures and prices. Catalog of other products will be sent upon request.

CUSTOM SCIENTIFIC INSTRUMENTS, INC.
541 Devon St. Kearny, N. J.
Tel.—WYman 1-6403



FOR FURTHER INFORMATION CIRCLE 416 ON READER SERVICE CARD

9 ways better at watching over you

Picker Gardray Radiation Badges

1 wide intensity range
Records exposures low as 50 mr, high as 300,000 mr.

2 wide energy range
Gamma, beta, x-rays (soft and hard) neutrons, single or mixed exposures.

3 "control" safeguard
Separate control badge guards against accidental fogging.

4 double-sure identification
1 code printed on wrapper
2 x-rayed on film

5 no loading or unloading
Wear badge as received, return it intact.

6 prompt reporting
Dependable, easy-to-read, too.

7 compact, lightweight
See size above: less than 1 oz.

8 attractive, unobtrusive
Clips on firmly, won't catch clothing.

9 durable
Secure snap-locks, won't come undone, won't break.

To subscribe, call any Picker X-Ray local office (see your 'phone book) or write to Picker X-Ray Corporation, 25 So. Broadway, White Plains, N.Y.

CIRCLE 417 ON READER SERVICE CARD

Laboratory Items

(*Continued from page 111*)

Boxes—Sterilizing pipet boxes of stainless steel, ideally suited for hospitals, laboratories, and other uses where cleanliness and sanitary storage are important, are now available.
George D. Ellis & Sons, Inc. 3250

Recording Systems—Available in 4-, 6-, and 8-channel models with a choice of five interchangeable preamplifiers, these new modular graphic recording systems will produce accurate traces on either standard roll chart or Epsco's Z-fold paper.
Epsco, Inc. 3251

Recording Balance—New attachment makes it easy to convert two-pan analytical balance into a recording instrument that automatically plots weight changes of a few tenths of a milligram up to 5 g.
Fisher Scientific Co. 3252

Polishing Apparatus—Metals difficult to polish by usual methods (such as tungsten, rhenium, molybdenum, and their alloys) can easily be polished with the aid of the new electrolytic lap-polishing apparatus, "Relapol." Using the Reinacher principle of electromechanical polishing, d-c voltage is applied to the specimen while slowly abrading it on polishing wheel covered with abrasive electrolyte slurry.
Wm. J. Hacker & Co., Inc. 3253

Pressure Gage—A new hydraulic peak-pressure gage that indicates peak pressures with full-scale ranges of 0 to 4000 and 0 to 10,000 psi has been developed.
Hydel, Inc. 3254

Dielectric Tester—The NF-Dekameter DK 04 developed for measuring the dielectric constant and the dielectric loss at a frequency of 800 or 1000 cycles is now available. Measurements in the low frequency range are of great interest to many branches of the chemical and electrochemical industry for the purpose of testing plastics, insulating materials, rubber, and many other items.
Kahl Scientific Instrument Corp. 3255

Liquid Cooler—This portabie liquid cooler is on casters so that it may be readily moved wherever desired. The coil can be immersed in glass jars, cans, or other type of containers. The control furnished with this cooler can be set to operate from 75 to 25 F at a differential of 3 F.
King Refrigeration Co. 3256

Wheatstone Bridge—A completely new and improved 4232-B high-precision guarded Wheatstone bridge is now being offered. The bridge provides complete guarding which eliminates errors caused by adverse humidity conditions and resulting leakage currents. This guarding assures accuracies of ± 0.01 per cent up to 1 megohm and ± 0.02 per cent up to 100 megohms. The bridge has wide measurement range—from 0 to 11,111 megohms.
Leeds & Northrup Co. 3257

Micro Gage—This new photoelectric instrument is a compact, highly sensitive device for measuring minute changes of light. It can be used for continuous measurement of small changes in strength of chemical solutions, mixtures, dispersions, etc. by detecting minute changes in light transmission. It can also be used as a strain gage in measuring very small deflections.
Lindly & Co., Inc. 3258

Oscillograph—A new model direct-recording oscillograph, the 621 Standard, has been announced. This instrument can record 8 or 14 data traces on 6-in.-wide recording paper.
Midwestern Instruments 3259

Direct-Recording Oscillograph—A new direct-recording oscillograph that is described as the lowest in cost-per-channel of the three members of the popular Visicorder family has been introduced. Known as the 1108 Visicorder, the new model is designed to allow high-speed recording of up to 24 channels of scientific and test data simultaneously.
Minneapolis-Honeywell Regulator Co., Heiland Division 3260

Chromatography Recorder—The Honeywell Series 143X chromatography recorder is an ElectroniK strip chart instrument, Specification S153–21, with features designed especially for vapor-phase chromatography recording. These features include continuous standardization, low-inertia pen carriage, high-resolution slidewire, and provision to add accessories such as a retransmitting slidewire, a manual chart-speed changer, limit switches, and recorder feet for portable use.
Minneapolis-Honeywell Regulator Co. Industrial Division 3261

Alpha-Beta Detector—A new instrument for detecting and measuring both alpha and beta-gamma activity in prepared samples is offered. Known as the PC-3A proportional counting system, it is designed for precision counting of hydrogen-3, carbon-14, calcium-45, and sulfur-32.
Nuclear Measurements Corp. 3262

Density Gages—For use on pipes through 8-in. in diameter, two new density gages are available for automatically measuring the specific gravity or per cent solids of liquids flowing through processing lines. Model PGV and PG both utilize a point source of radioactive material mounted in a safety shielded holder on one side of the line, and an Ohmart measuring cell on the other side.
The Ohmart Corp. 3263

Voltmeter—A new voltmeter intended for use as a laboratory standard instrument for checking all types of VTVM's is available. It features a high accuracy of 1 per cent or better from dc to 100 Mc.
Rawson Electrical Instrument Co. 3264

Transistorized Amplifier—A line of transistorized IF amplifiers utilizing silicon-tetrode transistors has been developed. Five models are available at the commonly used 30 and 60 Mc frequencies. Special units at any center frequency up to 80 Mc are available.
Remanco, Inc. 3265

Polishing Machines—A vibratory lapping-polishing machine providing easy, mechanical polishing of metallurgical samples for microscopic examination has been announced. Lapping pans range in size from 12 to 30 in. in diameter.
Syntron Co. 3266

High-Vacuum Pumps—Suited for general laboratory use, the new Series 150 UlteVac electronic high-vacuum pumps also have advantages for applications ranging from vacuum-tube processing to thin-film work. They produce clean ultimate vacuums below 1×10^{-9} mm of mercury.
ULTEK Corp. 3267

(*Continued on page 113*)

Laboratory Items

(*Continued from page 112*)

Vibration Instrument—An accelerometer sensitivity standardizer called the Dial-A-Gain converts all accelerometer sensitivities to a convenient 1 v per *g*, allowing direct reading of acceleration on any VTVM. The Dial-A-Gain includes a cathode follower input and a precision amplifier with a continuously variable gain control dial, calibrated directly in accelerometer sensitivities.
Unholtz-Dickie Corp. 3268

D-C Amplifier—A new laboratory d-c amplifier, Model DA-12, with noise of only 5.0 μv, peak to peak, a response time to a step function input of only 7 μsec, and overload recovery time of 50 μsec is announced.
United Electro Dynamics 3269

Furnace—Creating temperatures to 6741 F in seconds with heat flux densities of up to 365 cal per sq cm per sec, and permitting great flexibility and control in establishing environmental conditions, the solar furnace is a valuable and versatile tool for very high-temperature research and testing.
Waltham Precision Instrument Co. 3270

Black Body Cavity—A fixed-temperature calibrator for radiation pyrometers such as the Stoll-Hardy radiometer is now available. The cavity can be adjusted to any temperature between ambient and 65 C, after which it is left in continuous operation for an instantly available calibration check.
Williamson Development Co., Inc. 3271

News of Laboratories

Besser Co., Alpena, Mich.—A Materials and Methods Department to conduct routine testing of materials used in concrete block and to render consulting service is part of a newly established Besser Technical Center located in Alpena, Mich. The facilities of the center include rotary kiln, crusher, screen sieves, mixers, and vibrating table for processing laboratory specimens. In addition, complete aggregate bins, weigh batcher, spiral mixers, block machine, automatic unloader, lintel machine, and a 600,000-lb compression machine are available for commercial-size studies.

Instrument Company News

Branson Ultrasonic Corp., Stamford, Conn.—Manufacturer of ultrasonic cleaning and gaging equipment, has again expanded plant facilities. Construction has been completed on a 12,000 sq ft addition to the existing 24,000 sq ft building at 40 Brown House Road.

Catalogs & Literature

Spectrophotofluorometer—A new 8-page *Bulletin No. 2324* describing the Aminco-Bowman spectrophotofluorometer, an instrument designed to permit continuous activation of compounds and to measure the resulting fluorescence throughout the ultraviolet, visible, and infrared regions is now available.
American Instrument Co., Inc. 6136

Recorder—A 4-color brochure is available on the new Model 600 instrumentation recorder which offers a frequency response to 250 kc in direct recording and to 20 kc in FM work.
Ampex Corp. 6137

Dynamic Strain Measurements—A 24-page Bruel & Kjaer *Technical Review No. 3* describing industrial dynamic strain measurement techniques and procedures for analyzing the spectrum of complex strain signals is available.
B & K Instruments, Inc. 6138

Spectroscopy—*An Introduction to Emission Spectrochemical Instruments* is a new brochure briefly describing the basic principles of operation, typical applications, and the B/A line of emission instruments which include a complete 3-meter grating spectrographic laboratory, direct-reading spectrometers, and the research direct-reading spectrograph.
Baird-Atomic, Inc. 6139

Plastics—A 32-page *Catalog No. 959* lists a complete line of plastic laboratory equipment and supplies.
Bel-Art Products 6140

Analytical Balances—A new 12-page *Catalog No. 90* lists a complete line of Stanton analytical laboratory balances. Seven different balance types, including new thermo-recording and micro-chemical balances, are pictured and described in detail. Projection reading, improved weight-loading and ease of access to balance chamber are some of the features stressed.
Burrell Corp. 6141

(*Continued on page 114*)

Testing Results Are Valueless Without Reliable Measuring Instruments

Precision, often referred to as reproducibility, is the foundation on which rests the accuracy of any balance.

METTLER engineers have been acutely aware of this vital fact. They have designed and built the METTLER scales and balances for performance with the highest possible degree of precision. These modern instruments are the proper tool for the competent control engineer, who insists on reliable results.

Write today for the file on the complete METTLER line of fine weighing instruments.

METTLER INSTRUMENT CORPORATION
HIGHTSTOWN, NEW JERSEY

TYPE K-5
PRECISION SCALE
CAPACITY: 2000 grams
PRECISION: ±0.2 g

FOR FURTHER INFORMATION CIRCLE 418 ON READER SERVICE CARD

Catalogs & Literature

(*Continued from page 113*)

Voltmeter—Features, application, circuitry, and specifications of a d-c voltage standard and null meter are all included in a new *Bulletin No. 15-7* now available. The bulletin describes the KIN-TEL Model 301, a high-precision instrument that can be used to measure d-c voltages in the range of 1 to 501 v full-scale.
Cohu Electronics, Inc., KIN-TEL Div. 6142

Tension Gage—The CEC Type 5-050 dynamic tape tension gage for magnetic tape recorder/reproducers is described in a new *Bulletin No. 1621.* The gage permits accurate tension measurement and adjustment to be made quickly and easily on fixed or mobile tape transports.
Consolidated Electrodynamics Corp. 6143

Laboratory Catalog—A new 112-page catalog containing specifications for over 300 exclusive products used in the physical sciences has been issued. Items described range from optical benches and cathetometers to galvanometers and electron impact tubes.
The Ealing Corp. 6144

Accelerometer—A new 20-page, illustrated manual, *Endevco Series 2200 Accelerometers*, has been released. This manual combines the advantages of an instruction manual with thorough coverage of the "state of the art" in dynamic accelerometer methods and techniques.
Endevco Corp. 6145

Petroleum Manual—The new 1959 edition of the *Tag Manual*, contains 38 supplemental methods and tables. More than 40 pages of specific gravity conversion tables are reproduced from the latest ASTM-IP Petroleum Measurement Tables. Copies of the new 240-page Fisher *Tag Manual*, 29th edition, are $2.50.
Fisher Scientific Co. 6146

Laboratory Catalog—*Catolog No. 57* has a full line of laboratory instruments, glassware and apparatus.
Gardner Laboratory, Inc. 6147

Laboratory Catalog—A 16-page *Catalog No. 17* describes new equipment available including hot plates, balances, and pH meters.
Harshaw Scientific Co. 6148

Ovens—A new 6-page *Bulletin No. 159* describing a complete line of industrial heat processing ovens is available. Both batch type and semiautomatic continuous ovens are illustrated in this bulletin. These ovens are built in four general temperature ranges: 650, 800, 1200, and 1500 F maximum.
Hevi-Duty Electric Co. 6149

Testing Catalog—Catalog describing Amsler testing equipment and high-precision machine tools is available.
Carl Hirschmann Co., Inc. 6150

Data Processing—A new 48-page publication *N-07(1)* is available, describing data processing equipment in use, including digital data processing and analog and digital computing systems. Heavily illustrated, it explains types of inputs, input switching, output devices, and modes of operation for applications in electric power, petrochemical, aeronautics, agriculture, and other fields.
Leeds & Northrup Co. 6151

Furnace—Eighteen new product specification sheets covering the complete line of metallurgical testing furnaces, ovens, and accessories, have been combined into a single plastic-bound catalog. Included in the catalog are 6 tensile and creep-testing furnaces, 3 other special furnaces, 3 different control panels, and 2 high-temperature ovens.
Marshall Products Co. 6152

Servo Amplifier—The new Honeywell *Specification Sheet No. S900-4* contains the latest electrical and physical data on the Brown servo amplifiers as well as ordering information.
Minneapolis-Honeywell Regulator Co., Industrial Division 6153

Laboratory Catalog—A new 32-page *Catalog ELB-FC* describing various laboratory ovens and equipment is now available.
Modern Laboratory Equipment Co., Inc. 6154

Radiochemical Catalog—A new catalog-price list *Schedule E* devoted entirely to radioactive compounds, radiation sources, radioactivity standards, and radiation source kits is available.
Nuclear-Chicago Corp. 6155

Isotopes—A new 12-page booklet, *Industrial Radiography With Radioisotopes*, describing equipment and methods of radiographing all kinds of industrial products has been published.
Picker X-ray Corp. 6156

Thermostats—A new, 2-page illustrated *Bulletin No. T-5* describing a line of

(*Continued on page 116*)

A WEIGHTLESS WEIGHING SYSTEM

New Principle Advances The Science of Physical Testing

The Constant-Rate-of-Extension **method introduced by Scott Testers offers the highest accuracy and sensitivity ever for mill and lab testing of textiles, rubber, wire, plastic and paper products. Employing *electronic weighing*, this new Scott system is free from all errors of inertia and friction. It puts *ultra-precise* testing of your product's qualities on a practical and *economical* basis. Here's why:**

Push-Button Simplicity **lets you change test capacities *at a touch!* Electronic push-button controls take *all* the work and weight-handling out of physical testing. Load ranges, too, can be varied simply by interchanging force dividers in Scott's uniquely-designed load cell.**

High Magnification of Stress-Strain Curve **as high as 400 to 1, can be dial-controlled through chart travel speeds to get detailed test analyses. Electronic weighing automatically converts linear motion and measures test curves on a strip chart recorder.**

ADAPTABLE TO *ALL* SCOTT CLAMPS this versatile new method makes use of all Scott holding fixtures in conformance with ASTM, ISO, and Industry Methods.

Interested? Write for CRE Brochure today!

SCOTT TESTERS, INC. 120 Blackstone Street
Providence, Rhode Island

SCOTT TESTERS
THE SURE TEST . . . SCOTT!

CIRCLE 419 ON READER SERVICE CARD

Sodium aluminosilicates, Sodium aluminum brom
Sodium aluminum fluoride, Sodium aluminum hal
phates, Sodium [illegible]tes, Sodium alu
Sodium amide [illegible]rsenate, Sodiu
Sodium ammoni[illegible], Sodium ammon
monium phosph[illegible]um tartrate, S
monates, Sodium antimonides, Sodium antimonit
arsenates, Sodium arsenides, Sodium arseniphc
Sodium ar[illegible]osulfate,
cuprate, S[illegible] barbit
Sodium ba[illegible] barium ph
sulfate, Sodium barium triphosphate, Sodium b
Sodium beryllthioglufate, Sodium beryllate,
Sod[illegible] ber
liu[illegible]hate
bis[illegible]m b
muth citrate, Sodium bismuthides, Sodium bism
Sodium bismuth molybdates, Sodium bismuth sul
Sodi[illegible]thiog
state[illegible] Sodi
mate,[illegible] Sod
sol, Sodium butoxide, Sodium butyl phosphite,
mium chlorides, Sodium cadmium triphosphates,
Sodium calcium aluminates, S[illegible]cium car
ride phosphate sulfate, Sodi[illegible]nori
magnesium phosphate, Sodium [illegible]hosp
phates, Sodium calcium phos[illegible]s, S
oate sulfates, Sodium calci[illegible]sulfa
Sodium calcium sulfates, So[illegible]triph
Sodium [illegible]arbonate chromate,[illegible]ates,
Sodi[illegible]rbonatocobaltate[illegible]natoou
Sodi[illegible]inate, Sodium [illegible] ceriu
po[illegible]trite, Sodium[illegible]um nit
[illegible]um cerium tungsta[illegible]m oety

OVER 20,000 CHEMICALS IN STOCK!

Write for Our New 138-Page Catalog!

DELTA
PIONEERS IN CHEMISTRY

DELTA CHEMICAL WORKS, Inc.
23 West 60th St. New York 23, N. Y. PLaza 7-6317

CIRCLE 420 ON READER SERVICE CARD

Federal Government Standards Index Changes

THE FEDERAL Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for Procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplements 6 and 7 for the months of August and September, 1959.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity
Supplement 6, August 1959				
Flame Spread Properties of Materials	New	Int. Fed. Std. 00136(GSA-FSS)	...	GSA-FSS
Aluminum Alloy Bar, Rod & Wire (Free Machining)	Rev.	QQ-A-365b	9525 9530	DOD-USAF
Aluminum Alloy, Plate and Sheet	Am. 1	QQ-A-255c	9535	DOD-USAF
Aluminum Alloy, Plate and Sheet, Alclad 2024	Am. 1	QQ-A-362b	9535	DOD-USAF
Building Board, Asbestos-Cement, Corrugated	Rev.	SS-B-00750a (GSA-FSS)	5640	GAS-FSS
Copper Silicon Alloy; Rod Wire (Shapes and Flat Products), Flat Wire, Strips, Sheet, Bar & Plate	Rev.	QQ-C-591b	9525 9530 9535 9540	DOD-USAF
Cork and Rubber Composition Gaskets, Sheets, and Strips	New	HH-C-00551 (COM-NBS)	5330	COM-NBS
Molding Plastic, Polystyrene, Modified	Am. 2	L-M-525	9330	DOD-Navy-Ships
Pigment, Magnesium Silicate, Dry	New	TT-P-403a	8010	GSA-FSS
Primer Coating, Synthetic, Rust-Inhibiting Lacquer Resisting	Rev.	TT-P-00403 (GSA-FSS) TT-P-664a	8010	DOD-Army-ORD
Remover, Paint (Alkali Type)	Rev.	TT-R-230a	8010	DOD-Army-ORD
Steel Bars, Shapes, and Forgings, Corrosion-Resisting	Am. 2	QQ-S-763b	9510	DOD-USAF
Steel, Carbon Plate	Rev.	QQ-S-635	9510	DOD-Navy-Ships
Tape, Pressure-Sensitive Filament-Reinforced	Am. 1	PPP-T-97c	8135	DOD-USAF
Tape, Pressure-Sensitive Adhesive, Paper, Photographic	Rev.	UU-T-00123b (GSA-FSS)	6750	GSA-FSS
Terne Plate	Rev.	QQ-T-181	9515	DOD-Navy-Ships
Tube, Copper, Seamless (for General Use)	New	WW-T-00775 (Navy-Ships)	4710	DOD-Navy-Ships
Tube, Steel, Carbon, Mechanical, Round, Seamless and Welded	Rev.	QQ-T-830	4710	DOD-Army-ORD
White-Lead, Basic-Sulfate, Dry and Paste-in-Oil	Rev.	TT-W-261c TT-W-00261b (GSA-FSS)	8010	GSA-FSS
Wire, Electrical and Cable, Power, Electrical; Asbestos-and-Asbestos-Varnish-Cloth; Insulated	Rev.	J-W-850a	6145	GSA-FSS
Zinc, Sheet and Strip	Int. Am. 2	QQ-Z-301b	9535	DOD-Navy-Ships
Supplement 7, September 1959				
Diamyl-Phthalate, Plasticizer (for use in Organic Coatings)	Rev. Rev.	TT-D-291b TT-D-00291a (GSA-FSS)	6810	GSA-FSS
Ethylene Glycol Monobutyl Ether (for use in Organic Coatings)	Rev. Rev.	TT-E-776b TT-E-00776a (GSA-FSS)	6810	GSA-FSS
Matting, Rubber and Plastic (for use Around Electrical Apparatus or Circuits Not Exceeding 3000 v to Ground)	Am. 1	ZZ-M-81a	7220	COM-NBS
Molding Plastic, Polyvinyl Chloride Rigid	Am. 2	L-M-530a	9330	DOD-Navy-Ships

(*Continued on page 118*)

SYNTRON Vibratory

LAPPING MACHINES

provide precision flat surfaces easier, at lower cost—by continuous process lapping and/or polishing

SYNTRON Lapping Machines produce metallographic finishes and precision flat surfaces in production quantities easier and more uniformly than with old hand lapping methods.

SYNTRON Vibratory Lapping Machines work on an electromagnetic principle eliminating all mechanical wearing parts and assuring dependable service with low maintenance.

Available in sizes capable of handling parts up to 35″ in diameter.

Improve a product quality with SYNTRON Lapping Machines.

Write for free illustrated brochure

SYNTRON COMPANY

444 Lexington Avenue Homer City, Penna.

FOR FURTHER INFORMATION CIRCLE 421 ON READER SERVICE CARD

Catalogs & Literature

(*Continued from page 114*)

mercury-in-glass, fixed-contact thermostats, adjustable thermoregulators, and magnetic relays for laboratory, industrial, marine, agricultural, and other applications requiring a highly accurate and sensitive instrument is now available.
Precision Thermometer & Instrument Co. 6157

Laboratory Catalog—*Scientific Apparatus and Methods*, Vol. 11, No. 2, is now available. Micromolar analysis by conventional polarography is featured in this issue. The magazine also contains informative articles on the operations and applications of Sargent's new analytical oven and oil stability apparatus plus new products listed by the company.
E. H. Sargent & Co. 6158

Air Entrainment Meter—A new 6-page bulletin which describes a precision type of air entrainment meter to be used in testing and designing concrete mixes has been announced. The bulletin contains complete operating instructions and illustrations on the meter to enable the operator to obtain precise determinations of the air entrained in concrete.
Soiltest, Inc. 6159

Air Sampler—A new brochure *IH-4* provides detailed information concerning the Staplex Hi Volume Air Sampler, described as an instrument for the detection of radioactive particles, smoke, and smog; for atmospheric studies by weather services; and for detection of mine hazards and factory health hazards.
The Staplex Co. 6160

Tensile Testing—A 4-page illustrated booklet, *Bulletin No. T-859*, describes a line of tensile testing machines with capacities up to 40,000 lb. Specifications, descriptions, and methods of operation listed for manual and motorized hydraulic models are included.
Steel City Testing Machines, Inc. 6161

Environmental Test—The complete environmental test facilities located at Tele-Dynamics are covered in *Bulletin 859*. Charts and tables list equipment capabilities while photographs show the equipment in operation in the laboratory.
Tele-Dynamics, Inc. 6162

Melting Point Apparatus—A 4-page *Bulletin No. 133* describes the Hoover melting-point apparatus for fast, reproducible determinations of melting points, now offered with a periscopic thermometer reader for convenient and rapid observation of melting samples.
Arthur H. Thomas Co. 6163

Tensile Tester Grips—Five different sets of tensile tester grips are described in a new *Bulletin No. 101-TT* published recently. The Clark zero span grips and the well-known Tappi grips are among the models described in the pamphlet.
Thwing-Albert Instrument Co. 6164

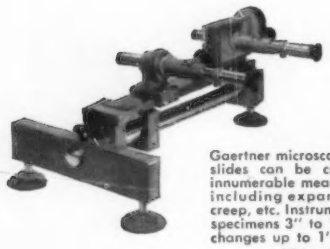
Vacuum Pumping Station—A new brochure is available describing a 2-in. high-vacuum station achieving pressures of less than 5×10^{-6} mm of mercury quickly.
Veeco Vacuum Corp. 6165

Thermometers—A complete specification sheet describing the basic thermistor thermometers, Models 43 and 44, is now available.
Yellow Springs Instrument Co., Inc. 6166

Other Societies' Events

December 16–18—**American Society of Agricultural Engineers,** Winter Meeting, Palmer House, Chicago, Ill.
December 27–30—**American Statistical Assn.,** Shoreham Hotel, Washington, D. C.
January 11–13—**National Symposium on Reliability and Quality Control,** Statler-Hilton Hotel, Washington, D. C.
January 11–15—**Highway Research Board,** 39th Annual Meeting, Sheraton-Park, Washington, D. C.
January 11–15—**Society of Automotive Engineers,** Annual Meeting and Engineering Display, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.
January 12–15—**Society of Plastics Engineers,** 16th Annual Technical Conference, Conrad-Hilton Hotel, Chicago, Ill.
January 20—**The Metallurgical Society of AIME,** Conference on Flat Rolled Products, Del Prado Hotel, Chicago, Ill.
January 22—**Engineers Joint Council,** Annual Meeting, New York, N. Y.
January 25–28—**Institute of Aeronautical Sciences,** Annual Meeting, Hotel Astor, New York, N. Y.
February 1–4—**American Society of Heating, Refrigerating, and Air-Conditioning Engineers,** Semi-Annual Meeting and Exposition, Baker Hotel

(*Continued on page 117*)



INSTRUMENTS TO MEASURE LINEAR DIMENSIONAL CHANGES

Gaertner microscopes and micrometer slides can be combined to satisfy innumerable measuring requirements, including expansion, contraction, creep, etc. Instrument above measures specimens 3" to 10" long and length changes up to 1". Reads to 0.0001". Write for details

For help with your optical instrumentation problems, call on Gaertner experience

Whatever your optical instrumentation problem, Gaertner Scientific Corp. can probably recommend a standard or modified instrument to meet your particular needs. If one is not available, we are fully equipped to design and build special instrumentation.

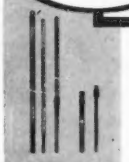
Gaertner has designed and built precision, scientific, optical and measuring instruments for 60 years. Write or phone, and put this experience to work for you

The Gaertner Scientific Corporation
1215 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

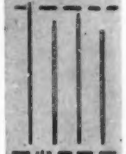
CIRCLE 422 ON READER SERVICE CARD

WEKSLER INSTRUMENTS

Precision = Accuracy

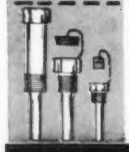


ENGRAVED STEM GLASS THERMOMETERS
• From 5" to 24", round or lens type. Ring or button top. Nickel plated brass or stainless steel armors.



A.S.T.M. THERMOMETERS
• Precision engraved stem glass thermometers manufactured to American Society for Testing Materials specifications.

HYDROMETERS & ACCESSORIES
• Quality instruments for all applications; light or heavy liquids, calcium chloride, spirits, sugar, petroleum products, etc.



SOCKETS AND TEST WELLS
• Separable sockets for use with indicating and recording thermometers. Test wells for engraved stem thermometers. In all metals.

For further information write to:

WEKSLER INSTRUMENTS CORP.
FREEPORT, L.I., NEW YORK

CIRCLE 423 ON READER SERVICE CARD

OTS Research Reports

(*Continued from page 100*)

The Preparation and Characteristics of Thin Ferromagnetic Films, PB 151525, $2.75.
The Preparation of Polycrystalline Ferrites for Microwave Applications, PB 151020, $1.50.
Preparation of Ferromagnetic Fine Particles from Bimetallic Oxalates, PB 151468, 50 cents.
Sanitary Protection of Atmospheric Air: Purification of Industrial Discharge Gases From Suspended Substances, 59-21092, $3.
The Degradation of Polymers by Ultraviolet Irradiation: Part 1—When Subjected to Radiation of the "Near" Ultraviolet Region in Air, PB 151411, 50 cents.
The Corrosivities of Plastics and Rubbers, PB 151750, $1.25.
Control of Variables in Heat-Resistant, Glass-Reinforced Plastics, Volume 1, Summary Report, PB 151802, $1.75.
Fire Prevention and Fire Protection, PB 151695, $3.
Sparking Characteristics of Metals, PB 151650, 50 cents.
Sparking Characteristics and Safety Hazards of Metallic Materials, PB 131131, $1.
A System for Automatic Processing of Fatigue Data, PB 151596, $3.
Magnetostrictive Drive Techniques for Fatigue Testing of Metals Above 10 Kilocycles, PB 151565, $2.50.
Testing for Notch Sensitivity in Welded Joints, PB 151630, 75 cents.
Survey of Literature on the Effect of Testing Temperature on the Properties of Wrought Copper-Base Alloys, PB 151306, $2.25.
Study of the Weldability of Aluminum Casting Alloys With 5086 Wrought Aluminum Alloy, PB 151307, $1.50.
Charpy-V Transition Temperatures of Ferritic Iron Alloys, Part 1—Iron-Oxygen and Iron-Aluminum, PB 151555, 50 cents.
Physical and Mechanical Properties of Nine Commercial Precipitation-Hardenable Stainless Steels, PB 151068, $2.25.
Properties of Certain Cold-Rolled Austenitic Stainless Sheet Steels, PB 151069, $1.75.
Development of High-Strength Filler Wires for Welding SAE, 4130, 4140, and 4340 Steels, PB 131074, $2.
The Strengthening of Austenitic Solid Solutions, PB 131992, $1.75.
Soil Mechanics and Earth Structures, PB 151613, $2.75.

Other Societies' Events

(*Continued from page 116*)

and Memorial Auditorium, Dallas, Tex.

February 1–5—**American Institute of Electrical Engineers,** Winter Meeting, New York, N. Y.

February 1–5—**Instrument and Automation Conference and Exhibit,** Sam Houston Coliseum, Houston, Tex.

February 2–4—**Society of the Plastics Industry,** Reinforced Plastics Div., Edgewater Beach Hotel, Chicago, Ill.

February 4–6—**American Society for Metals,** Metals Conference, Fairmont Hotel, San Francisco, Calif.

February 14–18—**American Institute of Mining, Metallurgical, and Petroleum Engineers,** Annual Meeting, Hotel McAlpin, New York, N. Y.

Bookshelf

(*Continued from page 84*)

Kinetics of High Temperature Processes

Edited by W. P. Kingery; John Wiley & Sons, Inc. (1959); 326 pp.; illus.; $13.50.

THIS WORTH-WHILE and timely volume comprises papers presented at a conference held with the support of the U. S. Air Force in June, 1958, at the Endicott House of Massachusetts Institute of Technology. The conferees represented various disciplines—chemistry, ceramics, metallurgy, and physics—and an opportunity was afforded for exchange of information and ideas. The discussions dealt with high-temperature processes in general, and with nonmetal systems in particular.

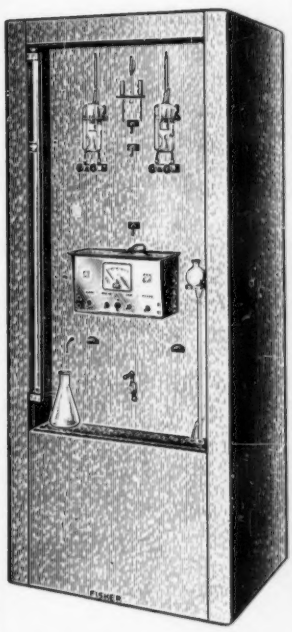
The papers in this volume fall into seven categories: (1) Imperfections and Diffusion in Nonmetals, (2) Diffusion in Liquids and Liquid-Solid Reactions, (3) Nucleation and Grain Growth, (4) Sintering and Vitrification, (5) Phase Transformations, (6) Solid-Solid Reactions, and (7) Solid-Gas Reactions.

The individual papers and discussions are of high quality. This volume will be of interest and value not only to workers in the field as a report on the current status of reaction kinetics, but also as an introduction to the subject for those new to the field. The book will be of particular value to teachers and graduate or advanced undergraduate students.

G. V. SMITH

NEW...

speed and accuracy for vapor pressure measurements



For testing • For research

FISHER MICRO VAPOR PRESSURE APPARATUS

Fisher is the first to bring you an apparatus for the important new *micro* vapor pressure technique.

Measurements with the Micro Vapor Pressure Apparatus can be made much faster and more accurately than Reid vapor pressure . . . and with samples of only 1 ml. Micro vapor pressure can be converted directly to Reid values.

The fuel researcher or engine designer will welcome the ability to get any vapor-to-liquid ratio, simply by varying the sample size.

Manufactured for Fisher under license from Esso Research and Engineering Company.

FISHER SCIENTIFIC

IN THE U.S.A. Boston, Buffalo, Charleston, W.Va., Chicago, Cleveland, Detroit, New York, Philadelphia, Pittsburgh, St. Louis, Washington. IN CANADA Edmonton, Montreal, Toronto

America's Largest Manufacturer-Distributor of Laboratory Appliances & Reagent Chemicals

WRITE FOR YOUR COPY of detailed bulletin that describes the Fisher Micro Vapor Pressure Apparatus.

107 Fisher Building Pittsburgh 18, Pa.

B-78b

FOR FURTHER INFORMATION CIRCLE 424 ON READER SERVICE CARD

the GENUINE BRINELL

HARDNESS TESTING MACHINES made by the Alpha Co. of Sweden and available from our stock at New Rochelle

Never approached in ACCURACY AND CONSTANCY of calibration . . . at the standard 3000kg test load . . . maximum error plus or minus 2½ kg

Write for Bulletin No. A-18

GRIES INDUSTRIES, INC.
Testing Machines Division
New Rochelle 2, N. Y.

CIRCLE 425 ON READER SERVICE CARD

THE NEW VERSATILE NON-DESTRUCTIVE COATING-THICKNESS TESTER

DERMITRON

Unit Process Assemblies, Inc., pioneers in non-destructive testing and specialists in electronics for metal finishing, offer their latest DERMITRON D-2 with these features:

■ Measures plated coatings on steel, brass, copper, zinc die-cast, aluminum, bronze and other metals; also, nickel on steel. ■ Measures anodize and hard-coat on aluminum and magnesium; also, paint, porcelain, organic coatings on non-ferrous metals. ■ Measures metal coatings on plastics, ceramics and other non-metallic materials. ■ Available with FOUR measuring probes for extra-wide thickness ranges from thin to thick deposits. ■ Only ⅛" circle area required for measurement. ■ You get fast, accurate, direct readings, plus versatility and portability. ■ Sorts metals and alloys.

Write for latest brochure and questionnaire to help solve your thickness testing problems.

UPA **UNIT PROCESS ASSEMBLIES, INC.**
61 East Fourth Street • New York 3, N. Y.

CIRCLE 426 ON READER SERVICE CARD

Federal Government Standards

(*Continued from page 115*)

Naphtha, Petroleum Aromatic (for use in Organic Coatings)	Rev.	TT-N-97a	6810p	DOD-Navy-Ships
Paint, Reflectorized, for Airfield Runway Marking (Drop-In Type)	New	TT-P-85a	8010	DOD-Army-CE
	New	TT-P-0085 (Army-CE)		
Pigment, Copper-Phthalocyamine-Blue, Dry	Am. 1	TT-P-350	8010	GSA-FSS
Pigment, Zinc-Dust (Metallic-Zinc-Powder), Dry	Am. 1	TT-P-460	8010	GSA-FSS
Pipe, Cast Iron, Bell and Spigot	Rev.	WW-P-421a	4710	DOD-USAF
Pipe, Clay, Perforated ..	Rev.	SS-P-00359a	5630	GSA-FSS
Soap, Automobile and Floor, Liquid and Paste	Am. 1	P-S-560	7930	GSA-FSS
Soap, Toilet, Liquid and Paste	Rev.	P-S-00624d (GSA-FSS)	8520	GSA-FSS

PROMULGATIONS

Title	Type of Action	Symbol or Number
Supplement 6, August 1959		
Continuous Identification Marking of Nickel and Nickel-Base Alloys	New	Fed. Std. No. 182

INDEX TO ADVERTISERS

ATLAS ELECTRIC DEVICES CO. 108

BUDD NUCLEAR SYSTEMS
A DIVISION OF THE BUDD CO. 101
BUEHLER LTD. 99
BURRELL CORP. 103

CADY & CO., E. J. 106
CENTRAL SCIENTIFIC CO. 102,104,106
CONSOLIDATED VACUUM CORP. 95
COSA CORP. 105
CUSTOM SCIENTIFIC INSTRUMENTS INC. 111

DELTA CHEMICAL WORKS, INC. 114

EASTMAN KODAK CO. 93
EBERBACH CORP. 94

FISHER SCIENTIFIC CO. 117
FORNEY'S INC., TESTER DIVISION 104

G. S. EQUIPMENT CO. 94
GAERTNER SCIENTIFIC CORP. 116
GENERAL RADIO CO. . . . . Inside Back Cover
GRIES INDUSTRIES, INC. 118

HOGGSON & PETTIS MFG. CO. 107
HUNTER SPRING CO. 2

INSTRON ENGINEERING CORP. . . . . Inside Front Cover

KLETT MFG. CO. 104

METTLER INSTRUMENT CORP. 113

NEWAGE INDUSTRIES, INC. 102

OLSEN TESTING MACHINE CO., TINIUS . Outside Back Cover
OZONE RESEARCH AND EQUIPMENT CORP. 99

PARR INSTRUMENT CO. 109
PERKINS, B. F. & SON, INC. 104
PICKER X-RAY CORP. 4, 112

SARGENT & CO., E. H. 3
SCOTT TESTERS, INC. 114
SIEBERG INDUSTRIES INC. 110
SMS INSTRUMENT CO. 110
SOILTEST, INC. 100
SYNTRON CO. 115

TATNALL MEASURING SYSTEMS DIVISION
THE BUDD CO. 96, 97
TESTING MACHINES, INC. 98
THERMO ELECTRIC MFG. CO. 107
THOMAS CO., ARTHUR H. 109
THWING-ALBERT INSTRUMENT CO. 119

UNIT PROCESS ASSEMBLIES, INC. 118
UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO. 120

WEKSLER INSTRUMENTS CORP. 116

PROFESSIONAL CARDS 90, 91, 92

Metals, Test Methods	Supp. A (Not. 1)	Fed. Test Method Std. No. 151
Ammonium Hydroxide, Technical	Am. 1	O-A-451d
Boxes, Fiberboard, Six or Eight Sides (Superseding PPP-C-570 (in Part)	New	PPP-B-655
Cable, Power, Electrical (Flexible Cord and Fixture Wire)	Am. 2	J-C-90a
Cloth, Cotton, Bunting, Mercerized (Superseding CCC-C-00439 (GSA-FSS) & CCC-B-791a)	New	CCC-C-439a
Desiccant, Activated, Calcium Sulfate, Anhydrous Superseding O-C-136)	New	O-D-210
Inhibitor, Corrosion, Liquid Cooling System	Am. 1	O-I-490
Pipe, Cast-Iron, Pressure (Gas and Water) (Superseding WW-P-00360 (GSA-FSS)	New	WW-P-360a
Pipe Fittings, Malleable Iron, Wrought Iron and Steel (Screwed), 150-Pound (Superseding WW-P-521c)	Rev.	WW-P-521d
Screening, Wire, Insect	Am. 2	RR-S-141a
Tape, Pressure-Sensitive Adhesive, Masking, Paper (Superseding UU-T-00106b (GSA-FSS) & UU-T-106a)	Rev.	UU-T-106c

Supplement 7, September 1959

Identification Marking of Aluminum, Magnesium, and Titanium	New	Fed. Std. No. 184
Adhesive, Vinyl Acetate & Resin Emulsion (Superseding MMM-A-00193a (GSA-FSS)	New	MMM-A-193b
Butyl Acetate, Normal (for use in Organic Coatings) (Superseding TT-B-838)	Rev.	TT-B-838a
Cloth, Cotton, Cheesecloth	Am. 1	CCC-C-440
Film, Radiographic, Industrial (Superseding W-F-00350 (Navy Ships)	New	L-F-350
Flasks, Laboratory	Am. 2	DD-F-250
Methyl-Ethyl-Ketone (for use in Organic Coatings) (Superseding TT-M-00261a (GSA-FSS) & TT-M-261)	Rev.	TT-M-261b
Molding Plastic, Polystyrene Modified	Am. 2	L-M-525
Molding Plastic, Polyvinyl Chloride, Rigid	Am. 2	L-M-530a
Packing of Fiber Boxes, Liners, and Sleeves, Knocked-Down, Flat	New	PPP-P-10
Paint, Blue-Lead-Base, Basic-Sulfate, Linseed-Oil, Ready-Mixed	Am. 2	TT-P-20
Paper, Index (Bristol) (Superseding UU-P-00258d (GSA-FSS) & UU-P-258c)	Rev.	UU-P-258e
Paper, Manifold (Superseding UU-P-00328d (GSA-FSS) & UU-P-328c)	Rev.	UU-P-328e
Paper, Mimeograph (Superseding UU-P-00388g (GSA-FSS) & UU-P-388f)	Rev.	UU-P-388h

INTERIM FEDERAL SPECIFICATIONS ISSUED

Title of Specification	Type of Action	Symbol or Number
(Supplement 6, August 1959)		
Pigment, Magnesium-Silicate, Dry	New	TT-P-00403 (GSA-FSS)
White-Lead, Basic-Sulphate, Dry and Paste-In-Oil	New	TT-W-00261b (GSA-FSS)
(Supplement 7, September 1959)		
Flame-Spread Properties of Materials	New	Int. Fed. Std. 00136 (COM-NBS)
Building Board, Asbestos-Cement, Corrugated	New	SS-B-00750a (GSA-FSS)
Cloth, Cotton, Chambray	New	CCC-C-00231b (GSA-FSS)
Cloth, Cotton, Sheeting	New	CCC-C-00432 (GSA-FSS)
Cord, Cotton, General Purposes, Sash and Venetian Blind	Am. 3	T-C-571b (GSA-FSS)
Cork and Rubber Composition Gaskets, Sheets, and Strips	New	HH-C-00551 (COM-NBS)
Diamyl Phthalate, Plasticizer (for use in Organic Coatings)	New	TT-D-00291a (GSA-FSS)
Ethylene Glycol Monobutyl Ether (For use in Organic Coatings)	New	TT-E-00776a (GSA-FSS)
Funnels, Filtering, Porcelain, Buchner	New	DD-F-00786b (HEW-PHS)
Paper, Kraft, Wrapping	New	UU-P-00268d (Army-QMC)
Pipe, Clay (Perforated)	Rev.	SS-P-00359a (GSA-FSS)
Pipe, Steel (Seamless and Welded, Black and Zinc-Coated (Galvanized)	New	WW-P-00404b (Navy-Ships)
Soap, Toilet, Liquid and Paste	New	P-S-00624e (GSA-FSS)

CANCELLATIONS

Title	Symbol or Number	Reason for Cancellation
(Supplement 6, August 1959)		
Cadmium-Yellow (Cadmium Lithopone), Dry (Paint Pigment)	TT-C-83	Superseded by Fed. Spec. TT-P-342
(Supplement 7, September 1959)		
Bunting, Cotton, Mercerized	CCC-B-791a	Superseded by Fed. Spec. CCC-C-439a
Buttons, Plastic and Pearl	V-B-00890 (Army-QMC)	Superseded by Fed. Spec. V-B-871b

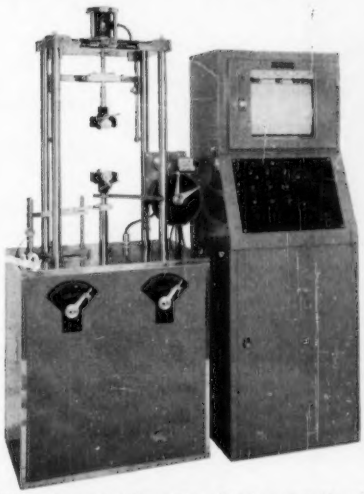
THWING-ALBERT ELECTRONIC TENSILE TESTER

An instrument for your present and future testing needs. Backed by over half a century of leadership and know-how in physical testing instrumentation.

Check these features:

Full scale ranges from 2 grams to 30,000 pounds
Sentronic "X-Y" Strip Chart Recorder
Infinitely adjustable pulling speeds
Adjustable chart magnification system up to 1000 to 1
Load and Extension Cycling
Simplified operating procedure
Grips and fixtures for every test—over 60 kinds
Electro-Hydraulic Pulling System

Thwing-Albert builds each instrument to your requirements. Many features can be added in the field. Your Tensile Tester can grow with your needs.



Write for more information; Send us samples of your material and learn how this versatile instrument can solve your testing problems.

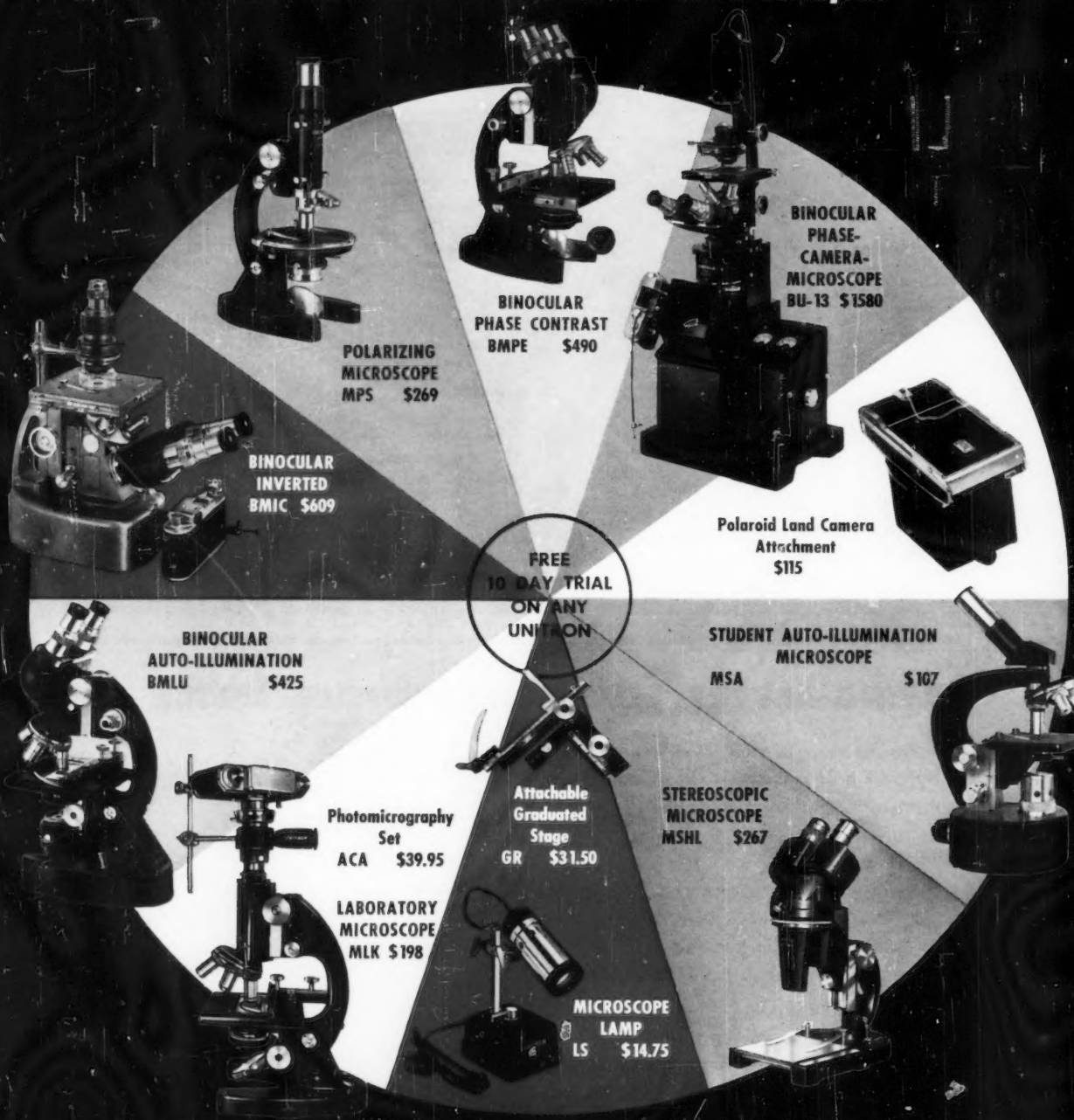
THWING-ALBERT INSTRUMENT COMPANY

5339 Pulaski Avenue **Philadelphia 44, U.S.A.**

#144

FOR FURTHER INFORMATION CIRCLE 427 ON READER SERVICE CARD

In the Laboratory . . . where optical quality counts . . . the trend is to UNITRON Microscopes


POLARIZING MICROSCOPE MPS $269
BINOCULAR PHASE CONTRAST BMPE $490
BINOCULAR PHASE-CAMERA-MICROSCOPE BU-13 $1580
BINOCULAR INVERTED BMIC $609
Polaroid Land Camera Attachment $115
FREE 10 DAY TRIAL ON ANY UNITRON
BINOCULAR AUTO-ILLUMINATION BMLU $425
STUDENT AUTO-ILLUMINATION MICROSCOPE MSA $107
Photomicrography Set ACA $39.95
Attachable Graduated Stage GR $31.50
STEREOSCOPIC MICROSCOPE MSHL $267
LABORATORY MICROSCOPE MLK $198
MICROSCOPE LAMP LS $14.75

UNITRON offers an extensive line of Laboratory Microscopes & Accessories for Research, Industry and Education. Illustrated is a partial selection for biology, medicine, chemistry and related fields. UNITRON also has companion instruments for the metalworking industries.

Noted for optical quality . . . advanced optical and mechanical design . . . unique and convenient operational features . . . long wearing construction . . . attractive budget prices which include basic optics . . . these, together with years of proven instrument performance, are the reasons why . . .

THE TREND IS TO UNITRON!

UNITRON

INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASSACHUSETTS

Please rush UNITRON's Microscope Catalog 3X

Name_____

Company_____

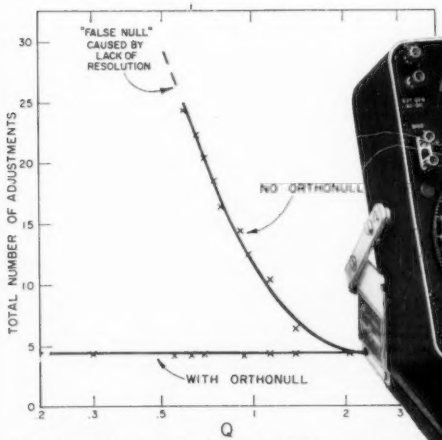
Address_____

City_____ State_____

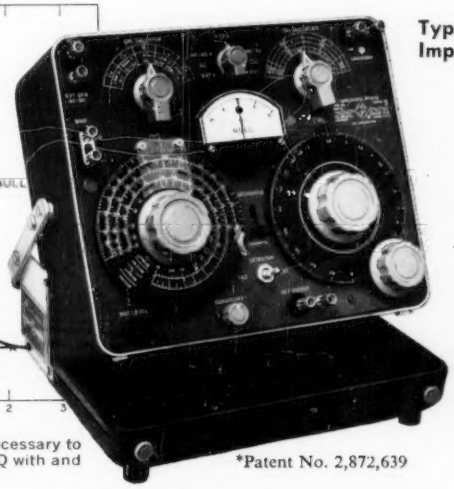
ORTHONULL

. . . No More Sliding Balances

The Orthonull* mechanism is an exclusive feature of G-R's new Impedance Bridge. Orthonull eliminates the annoying "sliding balance" that is common when measuring components having high losses with bridges that operate in the conventional nonorthogonal coordinate system. Basically, Orthonull makes the normally interdependent C, R, or L, and D (or Q) adjustments independent by making use of a unique unilateral ganging mechanism. With Orthonull engaged, adjustment of the CRL dial adjusts the DQ dial as well, cancelling electrical interdependence. Once the bridge is "locked on", convergence of the two adjustments becomes rapid, adjustment procedure is greatly simplified, and the danger of balancing to a false null is eliminated.



Plot shows the number of adjustments necessary to balance the bridge within 1% for a given Q with and without Orthonull.



*Patent No. 2,872,639

Type 1650-A
Impedance Bridge . . . $440.

OTHER FEATURES YOU GET IN THIS BRIDGE:

Wide Ranges — R: 0.001 Ω to 10 MΩ
L: 1 μh to 1000 h
C: 1 μμf to 1000 μf
D: 0.001 to 50 at 1 kc
Q: 0.02 to 1000 at 1 kc

Accuracy — 1% for R, L, and C
5% for D and Q

Ready to Use — battery operated with built-in transistorized null detector and 1-kc generator. Frequency range of bridge is 20c to 20 kc with external generator.

Unique Carrying Case allows panel to be tilted to any convenient angle . . . closes for complete protection.

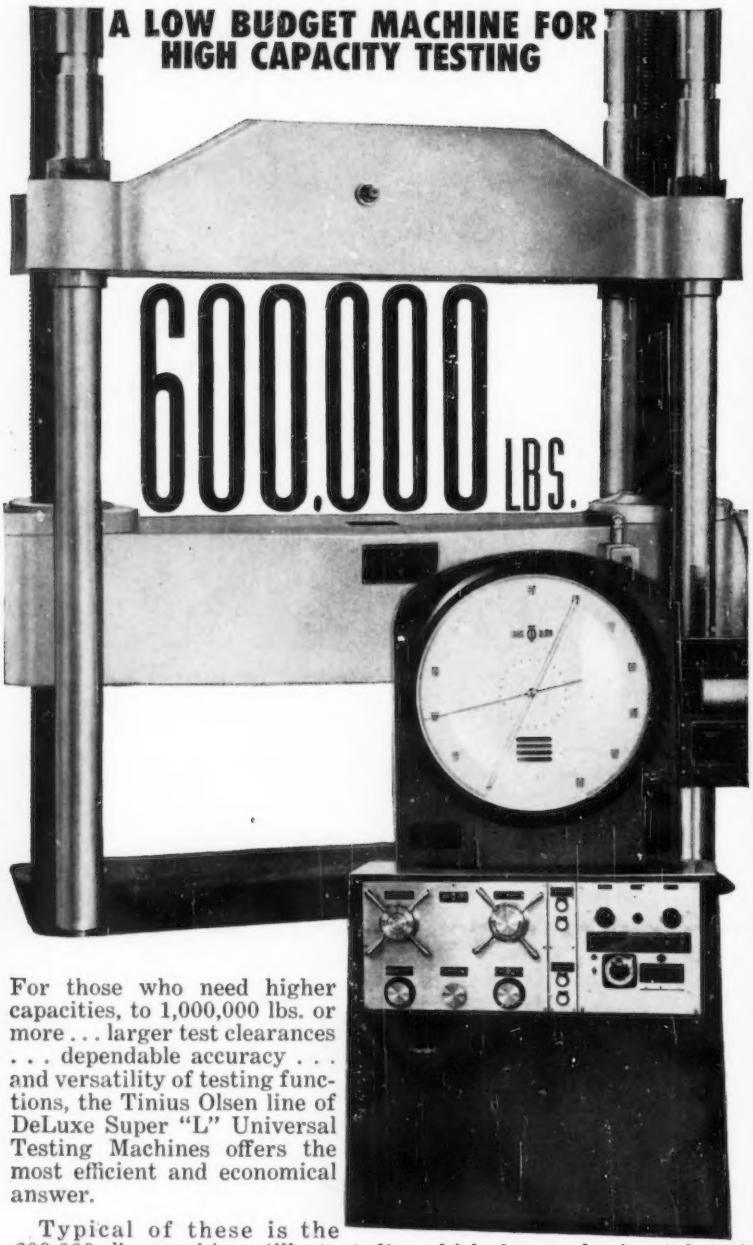
Write for Complete Information

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

NEW YORK, WOrth 4-2722 Ridgefield, WHitney 3-3140	CHICAGO Oak Park Village 8-9400	PHILADELPHIA Abington HAncock 4-7419	WASHINGTON, D.C. Silver Spring JUniper 5-1088	SAN FRANCISCO Los Altos WHitecliff 8-8233	LOS ANGELES Los Angeles HOllywood 9-6201	IN CANADA Toronto CHerry 6-2171

A LOW BUDGET MACHINE FOR HIGH CAPACITY TESTING



For those who need higher capacities, to 1,000,000 lbs. or more . . . larger test clearances . . . dependable accuracy . . . and versatility of testing functions, the Tinius Olsen line of DeLuxe Super "L" Universal Testing Machines offers the most efficient and economical answer.

Typical of these is the 600,000 lb. machine (illustrated), which has a horizontal test clearance of 62 inches. Load is applied by the friction-free Olsen hydraulic system, and accurately indicated on the Select-Range dial. Optional program controls can be set to automatically conduct a variety of cycling or variable loading tests. An electronic recorder together with choice of strain instrumentation produce precision stress-strain curves. Additional accessory controls, instrumentation and tools can be added as the need arises. In every detail, Tinius Olsen gives you the greatest return on your testing machine investment.

Write today for Bulletin 47-HC.

TINIUS OLSEN
TESTING MACHINE COMPANY

2020 EASTON ROAD • WILLOW GROVE, PA.

Testing and Balancing Machines

Trademark
Reg. U.S. Pat. Off.

REPRESENTATIVES

PACIFIC SCIENTIFIC CO.
Los Angeles and San Francisco, Calif.; Seattle, Wash.; Portland, Ore.

MINE & SMELTER SUPPLY CO.
Denver, Colo.; Salt Lake City, Utah; El Paso, Texas; Tucson, Ariz.

KINETROL COMPANY
Dallas, Texas

LABQUIP CORPORATION
Chicago, Ill.

TINIUS OLSEN
John C. Jensen
Livonia, Mich.

THE GIL OUTTERSON CO.
Cincinnati and Cleveland, Ohio

E. E. BOON
Pittsburgh, Pa.

H. G. GRAFF CO.
Boston, Mass.

F. R. JODON INC.
Washington, D. C.

THE ELLISON COMPANY
Atlanta, Ga.

Exclusive Canadian Representative
UPTON BRADEEN & JAMES LTD.
Toronto; Montreal; Hamilton; Windsor
Ottawa; Winnipeg; Edmonton; Vancouv

Soils Testing Only
KAROL-WARNER CO.
Highland Park, N. J.

FOR FURTHER INFORMATION CIRCLE 430 ON READER SERVICE CARD